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AERO DIVISION MEETING

The Aeronautical Division will hold its 2nd Annual Joint Meeting with the Institute of Aeronautical Sciences Summer Meeting in Los Angeles, California on Wednesday, 17 June 1959. Lt. Colonel James H. Polve, United States Air Force Academy will be Chairman of a panel discussion on "Is Our Present Aeronautical Engineering Obsolescent?" with such eminent authorities as Arthur L. Klein, CIT; John D. Akerman, Univ. of Minnesota; Col. Benjamin P. Blasingame, Air Force Academy; Wernher Von Braun, Redstone Arsenal and Leon Trilling, MIT.

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DO YOU KNOW . . . .

► . . . . That there is still time to make plans to attend the annual meeting at Pittsburgh? Things start with a bang Monday afternoon with a program having as its theme "Engineers for a Dynamic World." The outstanding speakers are W. L. Everitt, Allen Rogers, E. R. Sharp, H. L. Hazen, C. A. Brown, and E. A. Walker! On Tuesday comes the business session and presidential address, as well as F. C. Lindvall's report on the Russian Mission and an explanation of the year's work of CDEF. At the ECRC–ECAC dinner H. L. Rusch of Opinion Research Corporation will be the speaker. Wednesday is the ECRC sponsored "Guests of Industry Day," an innovation whereby everyone goes to a research laboratory for the entire day! "The Advantages and Disadvantages of a Common Core Curriculum versus Professional Fields Curricula in Engineering Education" is the theme for ECAC's General Session on Thursday. The Annual Banquet speaker is Dr. Dael Wolfle of AAAS. And you'll get to smaller group meetings and meet old friends and make new ones, too.

► . . . . That "Applications of Economic Evaluation in Industry" is the theme of the two-day summer school to be held in conjunction with the annual meeting—on June 13 and 14? Because of the "across the board" interest of all kinds of engineers in industry, the program has been called to the attention of other organizations, particularly those related to chemistry. The program is jointly sponsored by the Engineering Economy Division of ASEE and the Engineering Economy Research Committee of AIIE. For detailed information write to Professor G. J. Matchett, Director, National Center of Education and Research in Dynamic Equipment Policy, Illinois Institute of Technology.

► . . . . That a follow-up on General Education in Engineering is sponsored by the Humanistic-Social Division on June 18 and 19? Engineers are urged to attend the sessions to be held at Chatham College, Pittsburgh. Detailed information can be obtained from Dr. S. P. Olmsted, Rensselaer Polytechnic Institute.

► . . . . That an Office of Social Sciences has been established within the National Science Foundation? Dr. H. W. Riecken is its head. A program in support of basic social science research began about five years ago, but up to now has been associated with the program in the natural sciences. NSF believes it is proper and desirable to support basic research in the social sciences, since such support is invaluable in assisting social scientists to improve their research techniques, to accumulate fundamental knowledge about human behavior and society, and to develop sound theoretical bases for further inquiry.

► . . . . That an interesting program for the construction of better laboratory equipment in U. S. schools has been started on an experimental basis by NSF? The program is designed to encourage the development of inexpensive and practical tools for use in the laboratory phases of science instruction. Equipment for lecture demonstrations, laboratory and field work for courses at the elementary, secondary, and undergraduate college levels in mathematics, astronomy, earth sciences, physical and biological sciences, and engineering are included. Additional information can be obtained by writing to the Course Content Improvement Section, Division of Scientific Personnel and Education, National Science Foundation, Washington 25, D. C.

► . . . . That the earnings of engineers continue their upward trend? This is an over-all conclusion from EJC's third study of "Professional Income of Engineers." The over-all median for all graduates is $8,750 as compared to $7,750 in 1956 and $6,500 in 1953. The salaries of government employed engineers showed the greatest increases, but they are still not in a competitive salary position with industrial employees. Of the 190,810 engineering graduates included in the survey, 155,124 are in industry, 30,028 in Government, and 5,658 in education. Copies of the report are available from EJC, 29 West 39th Street, New York 18, New York for $3.00 per copy.

► . . . . That the invitation to place its Secretariat and administration of its program in EJC has been accepted by the U. S. Committee of the International Association for the Exchange of Students for Technical Experience? IAESTE is a non-profit organization with 24 member countries and has as its objective the placing of students of engineering and science in on-the-job training with industrial firms in foreign countries. A second objective is to build a foundation for international understanding and goodwill among these potential leaders and the host companies. In the past, the program has been operating at the Institute of International Education. For information in regard to the program write to Mr. Josef Wischeidt, Jr., Secretary, U. S. IAESTE Committee at EJC.

► . . . . That when the best liked interpreter for the Mission to Russia was asked how the group compared with others, he replied, "You are the most jolly old boys I have ever seen."

► . . . . That the Senate Armed Services Committee requested the Engineering and Scientific Manpower Commissions to present an amendment to H.R. 2260 which would extend the power of induction under the Universal Military Training and Service Act? In essence, the amendment authorized local boards to select registrants having critical skills for assignment to essential civilian activities for employment for a period of 72 consecutive months unless sooner released by the local board. Further, the registrant will not be subject to induction while satisfactorily serving in such essential activities except after a declaration of war or national emergency made by Congress. If the registrant fails to satisfactorily serve in essential activities he shall be subject, if not otherwise deferred, to induction into the Armed Forces. If 72 consecutive months have been satisfactorily served in essential activities, or if there is a sooner release by the local board, the registrant shall not be liable for induction, except after a declaration of war or national emergency made by Congress.

► . . . . That the undertaking of a sophisticated evaluation of the nation's long-range need for manpower in engineering and science is being considered by the Engineering Manpower Commission of EJC? Apparently no study has been made up to the present time which seemingly can be extended significantly without being radically altered by sudden temporary departures or for which the ultimate findings lack credibility. The task is a difficult one, but EMC may take the leadership because no other group intends to make such a study. Some believe the problem will eventually reduce itself to the inability of our society to provide in sufficient quantity the capable minds needed for the expanded demands of technology. During EMC's discussion of the subject it was stated that an AGCT

score of 120 or more is generally required for a student to be successful in engineering. And engineering can't claim all students of that ability.

► . . . . That past and present participants in du Pont's "Year-In Industry" program for engineering educators recently held a second reunion? This program, designed to provide a full year of study and intimate observation of widely diversified engineering operations was established in 1951 to "help bridge the gap between industry and engineering education." At the reunion attendees were given the opportunity to be brought up to date on significant advances in engineering technology and to discuss recent trends in engineering education with key management personnel. Anyone interested in details of the program should write to M. F. Wood, Chief Engineer, E. I. du Pont de Nemours & Company, Inc., Wilmington 98, Delaware. More than twenty engineering educators have participated in this program, among them ASEE President W. T. Alexander.

► . . . . That a revised "Personal Appraisal Questionnaire" is available from ECPD? It is designed for use by the young engineer who wishes to make a serious analysis of himself and his job and then plot a course to meet the established needs. Single copies cost 10¢. Professional development is a lifetime process, and the new version of "Your First Five Years" is as important in teaching as in any other area. To serve as a guide to the engineer in improving his ability to deal with men and affairs and his ability to read and absorb the written experience of others, ECPD also announces a revision of "Selected Reading for Young Engineers." The suggestions are in the fields of biography, travel, history, economics and sociology, psychology, philosophy, natural sciences, and general literature. Single copies cost 15¢.

► . . . . That at the recent meeting of the Nuclear Committee the role of technical institutes in providing personnel for the atomic energy programs in industry and in the national laboratories was discussed at some length? There were differences in opinion regarding the extent of the equipment that would be needed by the technical institutes but it was voted to recommend to the AEC that technical institutes be included in the AEC program for "assistance and acquisition of teaching and demonstration aids in nuclear energy technology."

► . . . . That there is a new source of information on "institutional" research? A Clearinghouse of Studies on Higher Education has been established in the U. S. Office of Education, Division of Higher Education. The Clearinghouse seeks to encourage new ideas and experimentation that will meet the challenge of an increasing college-age population, make easier the identification of institutional research, and eliminate duplication. The first issue appeared last January, and future reports are expected to appear at about six-months intervals. "The Reporter" consists of a list of titles of studies and includes a reference of from whom copies may be obtained. "Special Reports" consists of brief (4-page) summaries of the most significant programs and experiments recently instituted; this is a continuation of "Case-Book," which originated with the President's Committee on Education Beyond the High School.

► . . . . That the U. S. Office of Education has made an addition to its staff with the title "Specialist for Associate Degree and Related Programs?" Dr. Ken A. Brunner has been ap-

pointed to fill the position. The establishment of the position and the title is good news to all who are involved in technical institute education. Is this an indication that technical institute education in engineering and the awarding of the associate degree will not be lumped in with vocational and similar post-high school education?

► . . . . That the Technical Institute Evaluation Steering Committee has been appointed? Cecil Tyrrell of Broome Technical Community College is the chairman and the members of the committee are H. Russell Beatty of Wentworth Institute, B. C. Boulton of McDonnell Aircraft Corporation, K. A. Brunner, of the U. S. Office of Education, Maurice Graney of the University of Dayton, G. Ross Henninger of Ohio Mechanics Institute, H. H. Kerr of Ryerson Institute of Technology, C. H. Lawshe of Purdue University, Virgil Neilly of the Pennsylvania State University and W. C. White of Northeastern University. The specific charge to the committee is to make an evaluation study similar to that made a few years ago for degree granting institutions and resulting in the "Report on Evaluation of Engineering Education" and the related reports on General Education in Engineering, The Engineering Sciences, and Graduate Study in Engineering. The steering committee is to develop a program, method of operation, and a budget, seek the necessary funds, and cooperate with the President of the Society in selecting and organizing the working group to carry out the study.

► . . . . That though some people think too much pressure is being put on the teaching of science and mathematics in high schools the efforts to seek improvement must continue? In 1958 fourteen states did not require a single course in science or mathematics of students seeking a high school diploma! And since 1950 the number of qualified high school science teachers has decreased 53%. These are figures from the American Association of Colleges for Teacher Education. It looks as though raw material for our colleges of engineering might get worse before it gets better.

► . . . . That it is difficult to believe that this is the last issue of Volume 49 of the JOURNAL? This also is an alarming warning that in just a few days comes the Annual Meeting, the end of the fiscal year, and then the organization and planning for the year to come. As a boy my father told me the older you get the faster the years go by. I would argue with him and say that was impossible; they already went too fast. But how right he was; the increased rate at which the years go by is far greater than the difference in speeds of the horse and buggy and the orbiting satellities. The ever increasing rate at which time flies makes one wonder if what he accomplishes varies inversely. The years always end with so many things undone and with so many suggestions and ideas incompletely followed up or completely unexplored. The coming year always gives a little more time and, with the help of enthusiastic members, ASEE again will do its durndest to continue its record of accomplishments. And now, to each of you, a pleasant and profitabe summer, an enjoyable vacation, a raise in pay for next year, and a razor-sharp enthusiasm to do a better-than-ever job when another year opens in September!

W. LEIGHTON COLLINS
Secretary

FOUR MORE YEARS OF THE DRAFT

HOWARD A. MEYERHOFF

Executive Director
Scientific Manpower Commission
Washington, D. C.

In Washington the ominous threat of a Berlin crisis has been taken seriously—how seriously has been demonstrated by the dispatch with which the Congress considered and passed a virtually unmodified extension of the Draft Act. In the Senate hearings on March 3 Thomas H. Chilton, for the Engineering Manpower Commission of Engineers Joint Council, and Howard A. Meyerhoff, for the Scientific Manpower Commission, urged an amendment that would authorize local Selective Service boards to select engineers, scientists, and other critically occupied people for civilian service in essential activities, rather than for military service, with the understanding that such service in an essential activity for a stipulated period of time would satisfy their service obligation to the nation. Although the amendment was not adopted, General Hershey stressed the liberal policy of deferments Selective Service is currently using for critically occupied civilian personnel, including teachers and students. One of his statements, made in response to a question by Senator Saltonstall, merits quotation:

> This bill—I think in all fairness that this committee should know that this bill —as you extend it is not the bill that you passed four years ago. Its implementation has gone far beyond what anyone who saw it would imagine during the time of Korea because this is a different time. Therefore, when you extend this bill, you are extending what we are doing now, not what we were doing four years ago.

In answer to further questioning by Senator Case, of South Dakota, General Hershey went on to say that "I believe we [Selective Service] are accomplishing everything except one which they [EMC-SMC] want done. I don't think they are saying that we are taking the man out of industry. I think they are saying that he stays in industry and then gets no credit for it. That is, that after he has served three years, four years, six years, he still has an obligation. . . . Frankly, I may flatter myself to think that I understand the necessity of doing some of these things which the public has not yet arrived at the place where they are willing to give [military] credit for deferment."

General Hershey does not flatter himself. His administration of the Selective Service law and regulations has changed with the changing requirements of the times. Although his revised policies have not penetrated every part of the Selective Service System, engineers and scientists can have nothing but praise for the discretion General Hershey has used in the application of deferment policies to critical personnel. Nonetheless, the Draft Act remains unchanged in letter and the prospective draftee must observe certain ground rules that may profitably be summarized as follows:

1. To qualify for Class II-S (student deferment), a registrant must stand in the upper quarter of the male graduates in his senior class, or, failing that, he must have passed the Selective Service College Qualification Test with a grade of 80 or better.

2. A registrant who fails to meet either of these requirements will be classified I-A (available for induc-

tion), and it is pointless to appeal this classification. If, however, a college graduate who lacks the qualifications for deferment is not called for induction immediately, he may enter graduate school and can count on completing a year of work by using the I-S(C) classification. This automatically defers him until the end of the college year or, in special cases, until the end of the college semester. Reclassification as I-A at that time reopens the right of appeal, and a II-S classification can be sought, provided the scholastic record of the registrant during his first graduate year is excellent and warrants local board reconsideration.

3. No deferment is valid for a period longer than a year. At the expiration of a II-S or II-A deferment, the local board is likely to reclassify the registrant in Class I-A unless the registrant, with supporting evidence from the institution in which he is studying or the company by which he is employed, applies for a continuation of the deferred classification prior to its expiration or to local board action. In the case of graduate students, the request for continued deferment must be supported by Form 109.

4. Denial of a II-S or II-A classification at this point automatically opens the case to appeal to the state board. No local board has the authority to deny an appeal.

5. Work for the Master's degree must be completed within two years of the date of receipt of the Bachelor's degree; and a maximum of three additional years—five in all—is allowed for the completion of all requirements for the Ph.D. But renewals of the II-S classification must be sought annually, with supporting evidence from appropriate officials in the institution of learning that the registrant has maintained scholastic standards that will enable him to earn the Ph.D. degree within the time limit specified.

6. ROTC students may seek deferments, or delays, in assignment to active service, to undertake graduate work, but this must be done through the branch of the service in which they have been commissioned as reserve officers. The Army and the Air Force grant deferments more readily than the Navy, but in general it is desirable for the ROTC student to get his period of military service behind him just as soon as he receives the Bachelor's degree. There is no such thing as permanent deferment or exemption from service for ROTC graduates, and it is useless to inquire or to apply. In the Army, however, application may be made for six months of training, instead of two years of service, but for those who are accepted in the six months' training program the reserve obligation is lengthened.

7. Teaching is included in the list of essential activities; hence any teacher of engineering or science, as well as institutional employees engaged in research, may apply for occupational deferment (Class II-A). Deferment extends liability for service until age 35, and a method is provided for those who do not wish to incur extended liability to meet their obligation in the Critical Skills Program. Application must be made through the local board, and may be made even after the registrant receives a notice of induction. If accepted, the inductee is put through three months of training and, following discharge, is transferred quickly from the ready to the standby reserve.

8. Registrants who have passed their 26th birthday and have not fulfilled their military obligation are dropped to the bottom of the call list and, under present conditions, are not likely to be called into service. It is common practice to classify such men in Class I-A (available for service); hence they are especially vulnerable

(*Continued on page 978*)

THE YOUNG ENGINEERING TEACHER'S RESPONSIBILITY FOR HIS OWN PROFESSIONAL DEVELOPMENT

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Condensed from an address delivered October 23, 1958 at the Young Engineering Teachers Conference of North Midwest Section of ASEE held at the University of Wisconsin.

A review of the literature reveals that there is a relatively large amount of published material which bears in one way or another on the broad subject of the professional development of the young engineering teacher. But the same analysis discloses that, related to the topic as they are, very few of these articles use the phrase "professional development." Therefore it is hard to escape the conclusion that relatively little *explicit* attention has been paid to the subject of the engineering teacher's professional development as such.

By contrast, the literature specifically discussing the professional development of the engineer in industry is more extensive. Because I take it to be axiomatic that the professional development of the engineer in industry and that of the engineer in teaching have much in common, a considerable portion of what follows will simply be an attempt to restate, in terms of the educational scene, some of the more clearly formulated concepts relating to the professional development of the engineer in industry.

Naturally, there are also some unique features about the educational enterprise which prevent us from dealing with our subject solely by analogy with the industrial case. Of these, the feature which has the most bearing on the material to follow is the fact that the engineer in teaching is a member of two professions, not one. Teaching, usually referred to as one of the "learned professions," demands forms of professional growth for which the engineer in industry has no direct concern. Even if the engineering teacher regards his membership in the teaching profession as somewhat secondary to that of the engineering profession, it nevertheless remains true that unless he develops, in some way, professional competence as a teacher as well as an engineer, he thereby jeopardizes the effectiveness of his unique role in society.

Accordingly, in what follows I shall find it convenient, for analysis, to discuss separately the professional development of the young engineer as *teacher* and as *engineer*. I am not trying thereby to divide the engineering teacher into two unrelated parts; it is the single composite creature, who is *simultaneously* engineer and teacher, that concerns us. But I feel that we will understand the composite better if we take the opportunity to investigate separately these two aspects of one and the same person.

A note about terminology is in order here. In what follows, I shall use the term "engineering teacher" in two senses, a literal sense and a broader sense. In the literal sense, "engineering teacher" shall mean one whose principal activity is that of teaching. But you will recognize that there are

many who perform important roles in engineering education who, strictly speaking, do little or no teaching, such as people who devote almost all of their time to administration, research, or counseling. I have therefore sometimes used the term "engineering teacher" to include anyone holding a responsible role in engineering education. Actually "engineering educator" would be a more precise general term and I have employed it where convenient.

Before entering into a more detailed consideration of *our* responsibilities for *our* own professional development (I speak as a colleague and not as an authority on the subject), let me belabor the obvious by insisting that, while such professional development is a matter of teamwork, with the schools, industry, the professional societies, and the community all playing a part, the role played by the engineering teacher is such that without it even the most zealous activities of the other members of the team will be to no avail. In the final analysis, all they can do is to provide "conditions of growth," an "atmosphere" in which the young engineering teacher feels challenged to grow to full professional stature. Without the inner vitality of the young teacher, without a desire on his part to grow, no amount of conducive professional climate will produce results. Therefore, the most crucial responsibility we have is to actively seek to make maximum use of the opportunities for professional growth provided by industry, the schools, the professional societies, etc.

Let me begin the more detailed analysis of our responsibilities by stating that I view the development of the engineering teacher as a three-dimensional challenge. Therefore, I shall discuss, in the order mentioned, the development of the young engineering teacher as "person," "citizen," and "specialist." While it might seem out of place to discuss one's development as a person and a citizen as part of "professional" development, let me point out that in so doing I will not be departing significantly from the literature on the professional development of the engineer in industry (though I will be phrasing things in a slightly different way). Furthermore, even though development as a person and a citizen make little direct contribution to one's competence as an engineering teacher, all these aspects of development should be going on simultaneously in one and the same person and consequently need to be considered side by side.

The Teacher as a Person

One of the most fundamental principles of a democratic society is its belief in the dignity and worth of the human person. The individual person is much more than an instrument of the state or a highly specialized automaton. By development as a "person" I mean nothing more nor less than our preparation to live rich and meaningful personal lives. Were our development to be geared strictly to preparation for our lives as citizens and specialists, it might be a very lopsided development indeed. An engineer can eke out an existence, in fact, could conceivably become quite wealthy in a material way, without any knowledge of or appreciation for some of the noblest expressions of the human spirit as recorded in the masterpieces of poetry, music, art, and literature which are part of the riches of our human heritage. We do not seek to transmit the cultural heritage to new generations for its practical value. We do so because without it their lives are somehow impoverished, are somehow less than fully human. The brute animal is content when his belly is full and his mating instincts satisfied. But man is capable of and

deserves a richer existence than biological survival; truly man does not live by bread alone. The full development of our human potentialities might very well contribute to our development as citizens and as engineers. If so, it is a welcome by-product but ultimately we seek our personal development simply because it enables us to lead lives as befits human persons.

For good practical reasons, our formal education, like that of our students today, at best laid a groundwork for further personal development. We exhort our students to continue this development after graduation; the literature of the ECPD Professional Training Committee urges the engineer in industry to develop a program of continued reading and study for this purpose. Consequently, over and above the value of this personal development to us as individuals, if our students are to take to heart our admonitions, we must be examples, *par excellence*, of the "well-rounded" human beings we urge them to become. They must not see us as narrow specialists with no interests outside some little niche of the technical domain. Even though it may not enter directly into our classroom activity, the richness of our personal lives cannot but surround all that we do with an atmosphere which adds to our total impact on the student what the higher harmonics and overtones add to a "highly-specialized," single-frequency musical note. We therefore have a grave responsibility to avail ourselves of the opportunities for personal development provided by our communities (both civic and academic). If these opportunities are not adequate, we must fall back upon our own resourcefulness in this area. The responsibilities to prepare to lead a life which is as rich and full as possible apply, in different ways, to every member of the human race, regardless of the nation of which one is a citizen or of the occupation of which one is a practitioner.

The Teacher as Citizen

The second dimension of our development is that of "citizen" and it superimposes on our need for personal development those additional obligations deriving from our responsibilities as citizens of a nation. These obligations of citizenship are especially demanding in a democratic society such as ours. The continued existence of our democratic way of life is imperilled if large numbers of citizens disdain to exercise their responsibilities, or worse yet, do so in a capricious or irresponsible manner.

As part of his development, the engineer in industry is urged to strive for "integration into the community," is urged to take part in civic and community affairs. This same message, amplified somewhat, might well be beamed at the engineer in teaching, lest he be a "parasite" who enjoys the blessings of democracy without sharing in the sacrifices necessary to perpetuate it. There are appearing dangerous inroads on the cherished academic freedom of teachers and scholars. The term "egghead" has been popularized. These events appear to me to be evidence that the less well educated citizens do not understand the inhabitants of the academic world. If this be so, does not the fault lie with the highly educated man who fails to be articulate, who disdains to immerse himself in the life of his community so that he may make the unique contributions of which he is capable and simultaneously dispel the misconceptions which abound in the popular mind? As young engineering teachers we have a grave responsibility to make growth as citizens an integral part of our program of development.

Development as Engineer

The third dimension of our development is that of "specialist" and superimposes on our need for personal and civic development the obligations of preparing to make some unique contributions to society. Therefore, we must now consider in detail our development for performance of our specific duties as engineering teachers. As stated earlier, for analysis only, I will consider separately our growth as *engineers* and as *teachers.*

Taking the professional development as engineer first, I find it convenient to subdivide this also. Just as each citizen has both *general* obligations as citizen and also a *special* role to play in society, so too, each member of the engineering profession has certain general responsibilities as a professional man as well as the need for some special area of professional competence. Therefore I feel that every engineering teacher, regardless of his technical specialty, must concern himself with the development he needs in order to understand and cope with the broad problems of the engineering profession—its unity or lack thereof, its ethical standards, its relation to labor unions, etc. The engineering teacher should be aware of and support the activities of the agencies and professional societies which give particular attention to broad issues such as these. In my opinion, no engineering teacher has reached professional maturity who has a "blind spot" in relation to his general responsibilities as a member of the engineering profession.

To ascertain the manner in which we develop in our specific engineering fields, let us investigate the roles of the schools, industry, and the professional societies. We see immediately that the schools make two different types of contributions, which fact is best illustrated by visualizing the situation where an engineering teacher is employed by one institution while taking advanced graduate work at another. As providers of graduate work, schools contribute to our professional development by providing opportunities for the advanced technical education without which we could not hope to achieve top stature as engineering teachers.

As employers, the schools contribute to our growth as engineers through various types of "in-service" training programs. Assigning the teacher to a variety of related courses over a period of time is one such way of enhancing his technical maturation. Provision of staff seminars on advanced topics, given by local or imported specialists, is another device. Assisting the young engineering teacher in developing a research program, making it possible for the teacher to undertake consulting work when available, and encouraging his participation in technical society activities are still others. It is clearly the responsibility of the young engineering teacher to take full advantage of all such opportunities as may exist.

Industry contributes to our professional development as engineers through the opportunities which it provides for employment during leaves of absence and summer periods. Furthermore, though relatively few young teachers are so blessed, many companies maintain a continuous relationship with selected engineering teachers by offering them consulting work.

Because one of the basic purposes of the technical societies is the development and maintenance of the professional statures of their members, the role of these societies in our development as engineers is clear. Through their publications, through the sponsorship of local, sectional, and national meetings at which new technical developments are presented, and through the provision of opportunities to serve

on various technical committees, these societies provide the young engineering teacher with opportunities to develop as an engineer. The young engineering teacher who feels a responsibility for his own professional development will lose no opportunities to capitalize upon such avenues as are provided by industry and the technical societies.

Development as a Teacher

Let us now look at our professional development as teachers or educators. Just as I chose to divide the development as engineer into two components, general and specific, so too I would like to suggest two distinguishable aspects of our development as educators. The first is the general responsibility which we have as "citizens" of the academic world. Just as a democratic society is imperilled if its citizens go about their special jobs and ignore their general responsibilities as citizens, and just as the engineering profession suffers because so many of its members concern themselves only with their engineering specialty to the neglect of their duties to the profession as a whole, so too our educational system is beset by countless educators who see only their tiny little niche of the educational picture and who know little (and care less) about the overall educational problems of the day. Regardless of what our special contribution to engineering education might be, almost certainly we are called upon to pass judgment (in committee work) or to vote (at faculty meetings) on issues which are more general than those we confront in our day to day tasks. How can we exercise intelligently these voting "rights" as citizens of Academe if we have not developed the background to understand the problems and issues?

In the fond hope that they may be more intelligent and responsible citizens, our young people are made to study their nation's history and traditions, its constitution, the organization and functions of the various branches and levels of government. They are exhorted to keep up on current events. We are appalled when studies show how frightfully ignorant some voters are of candidates and issues. Yet I must confess that I fear that were most educators tested regarding basic "facts of life" in the educational world, they would make these poor citizens look like quiz kids. I'll wager we'd all be surprised at how few engineering teachers could tell you, within plus or minus 30%, how many accredited engineering institutions we have in this country, or how many students receive bachelor's degrees in engineering each year (much less how many receive doctorates). How many of us have a quantitative grasp of the current and projected engineering teacher shortage? Are these not things of concern to us all? Any young engineering teacher who has no awareness of and no sense of responsibility toward the broad problems of engineering education is a long way from professional maturity. It is high time more of us learned something about the educational system of which we are a part and whose destiny, God help it, will some day be in our hands. When we have informed and responsible educators, our problems will begin to fade; until then, the problems can only grow more pressing and unwieldy.

Now let us turn to the final area, the development for our specific duties as educators. First of all, I would like to stress the wide diversity of functions within engineering education. To be sure, almost all of us enter our careers in engineering education via the same portal—teaching. In fact, in the earliest years that is almost certainly our sole function. But within a relatively short time we

begin to accumulate responsibilities which, strictly speaking, are not teaching. We get on a curriculum committee, we get a tiny dose of administrative responsibility by being in charge of a multi-section course, we become faculty advisors to a student chapter of a professional society, we act as counselors for sophomores, etc. These non-teaching functions are an integral part of the educational scene, but for most of us they play only a minor role in our academic careers. Some form of teaching remains our principal responsibility. But I think it is important to note that exceedingly few mature engineering educators do teaching *only:* we each must expect to perform, and perform well, some of these other functions.

Furthermore, it is not at all uncommon for some engineering educators to be challenged to assume positions where teaching ceases to be their principal responsibility. Some do almost full-time research; for others the area of counseling becomes a specialty. Still others assume major administrative duties which may even reduce to zero their participation in teaching. My whole point is that engineering educators are necessarily (and fortunately) a very heterogeneous group. No one but a true genius could aspire to consummate competence in all the functional areas of engineering education. Each of us must gradually discover that limited constellation of functions which we find rewarding and then make our contribution to engineering education by striving to discharge our duties in our chosen area at the highest level of professional competence of which we are capable.

Before leaving this subject of diversity, I would like to point out that, even for the majority of us for whom teaching will remain our principal function, there is still more specialization. Teaching duties cover a formidable array of different types and levels of courses. There are freshman orientation courses; introductory courses for majors; "service" courses for non-majors, "terminal" courses for seniors going directly into industry; advanced undergraduate (or basic graduate) engineering science courses; highly specialized, low enrollment graduate seminars; etc. How many teachers are to be found who are capable of (let alone disposed to) flitting from one end of the educational spectrum to the other every other day, or even every other term? Is it fair to ask a man who is disinclined to do so to shift mental gears and teach sophomores one period and a few research disciples the next? It takes time and effort to build up a course to top quality and to maintain it. Hence, I see no alternative but to admit that each of us must eventually find those curricular areas which are most challenging and then intensively cultivate them. Let us hope that the administrative climates in which teachers work will be such that real contributions in all areas are recognized in their own terms so that teachers will not be compelled to shun certain areas (e.g., "service" courses) for fear of committing professional suicide. Woe to engineering education if all teachers aspire to teach only the very advanced "prestige" courses, accepting the more "menial" assignments under gentle forms of duress and with the attitude of taking their turn and getting it over with as painlessly as possible.

I repeat, engineering educators are a heterogeneous group. Assuming the requisite competence, almost anyone can find a challenging and rewarding domain of responsibilities within which to develop to top professional stature. Our dual responsibility as young engineering teachers is to discover our role in engineering education and then to follow the avenues of professional growth therein.

Patterns of Growth

Plotting our individual patterns of professional growth as educators in more concrete terms than the above is difficult because of the diversity of our professional goals. Nevertheless, I will make a few remarks in this area. There is one point on which I shall not spend much time, because it is so obvious, but which I do want to mention briefly, lest you get a mistaken notion of my estimate of its importance. Earlier we considered the professional development of the young engineering teacher as engineer. Those things which contribute to the engineering teacher's technical mastery of his field obviously thereby also enhance his ability as a teacher, in a way for which there is absolutely no adequate substitute. Subject-matter competence is a *sine qua non* of good teaching.

But there are a variety of other ways in which industry, the professional societies, and the educational institutions can and do contribute to the engineering educator's ability to discharge both his general and specific educational responsibilities. Some industrial organizations have sponsored various types of special conferences for engineering teachers, some of which conferences have been devoted to the consideration of educational rather than purely technical problems. Teachers who have a major responsibility for counseling students regarding forms of industrial employment would profit more by periods in industry spent in getting deeper insights into an overall industrial operation than by employment on some highly specific technical assignment (valuable as that is in other ways).

The professional society which makes a large contribution to the development of engineering educators as educators is ASEE. It performs a function which the specialized technical societies cannot perform, that of binding all engineering educators in a common society dedicated to the solution of our common *educational* problems. The promotion of the professional development of the young engineering teacher is the very purpose of the ASEE Committee for Young Engineering Teachers (CYET). CYET carries on activities at the local, sectional, and national levels, all ultimately aimed at our professional development. Furthermore, there has been in the talking stage for a number of years a full-blown summer school for young engineering teachers. When and if it materializes, ASEE will have been responsible.

In my opinion, there is one serious weakness in ASEE in connection with its efforts to promote the development of engineering educators. This weakness is the almost total absence of a grass roots organization. At only a handful of institutions do there exist Branches of ASEE, and a number of these are little more than paper organizations. Were dynamic Branches to exist in the vast majority of institutions, ASEE would be more able to extend its beneficial influence to its individual members down on the firing line.

In analyzing the contributions of the educational institutions, as before, it will be expedient to separate their two roles as suppliers of academic work and as employers. Considering the first of these two, apart from the value of advanced technical courses (which has already been mentioned), very little by way of formal course work is available directed toward one's development as an educator. There is one institution which offered two graduate courses in engineering education, one historically oriented, the other a seminar of current issues. Other than this, about the only other available courses are those on "college teaching" which are offered at a number of institutions at which engineer-

ing schools are located. These courses vary greatly in quality and content but in general strive to achieve either or both of the following objectives: (1) assist the student in developing competence for his specific educational duties (teacher, counselor, etc.), and (2) give him the background material which enables him to understand the system of higher education and his part in it. Relatively few engineering teachers enroll for these courses; those that do are by no means uniformly pleased with the results. It would seem that some pioneer work needs to be done in this area.

The absence of formal courses in "engineering education" is, in my opinion, no great tragedy if the institution which employs the teacher has an adequate program of in-service training. There are a number of analogies between the in-service training programs which industrial companies have for the development of their engineers and those which schools have for the development of their teachers. Accordingly, the development as educator begins in a number of engineering schools with orientation programs for new faculty members (new to the institution or new to teaching). This assists the newcomer in understanding his new institution and his place in it.

In a few institutions, the orientation is not confined to a one-shot affair at the beginning of the academic year but is prolonged at least through the first term by means of periodic meetings. Topics include both broad problems of engineering education and specific problems of teaching techniques, evaluation of student performance, etc. These are an exceptionally valuable contribution to the professional development of mature engineering educators.

Tactful supervision of apprentice teachers is another critical element in the institution's responsibility for the development of its staff. Fortunate is the young teacher who receives sincere offers of guidance and direction from experienced colleagues; foolish is he who does not avail himself of it.

In the development of its staff, apart from the fact that it must do so for the sake of its own operation, the school does the young aspirant a great service through periodic appraisal of overall professional growth. When this is done in the more or less mechanical way of counting degrees and publications, it loses much of its value. The young teacher who has been privileged to work under a really outstanding administrator knows the value of the frank and confidential appraisal, of the person-to-person discussion of strengths and weaknesses.

In a few other less critical ways, the institution assists the young teacher in his development as teacher. It sees to it that he experiences a variety of teaching situations—the laboratory, the large lecture, lecture-recitation classes, problem sessions, etc. The school offers the developing teacher opportunity to broaden his horizons as an educator by assignment to committees coping with educational problems—curriculum, facilities, etc. Finally, by encouraging participation in ASEE activities, the school can help the teacher to advance his maturity as an educator.

The Key Ideas

In review, our responsibility for our own professional development boils down to a handful of key ideas. The young engineering teacher must first of all be aware of his professional immaturity and anxious to embark on his professional growth. For his own sake and for its subtle effect upon his students, the young engineering teacher has a responsibility to promote his growth as a "person." The teacher must also see to his civic responsibilities, the more so because some public misunderstanding and distrust have

resulted from the absence of scholars in community affairs. In planning our specialized development as engineering teachers, we might profitably distinguish between development as an engineer and development as a teacher. Each of these in turn is best understood in terms of a distinction between general and specific responsibilities. We all enter careers in engineering education in much the same way but we have the responsibility to gradually select from the gamut of possibilities open to us those which we find most satisfying. This done, we must chart our course to full professional stature and pursue it with vigor, tact, and tenacity. We have the responsibility of making use of every helpful element in the "atmosphere" provided by the schools, industry, the professional societies, and our communities. If the atmosphere is missing some of the elements it might best have, we must show our hardiness by achieving some measure of growth in spite of such handicaps. The world of engineering education is in dire need of mature citizens; let us be about our business!

FROM C.Y.E.T., NORTH-MIDWEST SECTION, ASEE

The North-Midwest Section Conference for Young Engineering Teachers was held at the University of Wisconsin, October 23–24, 1958. The two-day conference, which preceded the Annual Meeting of the North-Midwest Section, ASEE, took as its theme, "The Young Engineering Teacher—His First Five Years of Professional Development." This was carried out as small group (15–20) discussion-type meetings following short key-note addresses with topics and speakers as follows:

"The Responsibility of the Individual—"	Professor Harold A. Foecke, University of Notre Dame.
"What Industry Can Do—"	Mr. James H. Foote, Commonwealth Associates, Inc., Jackson, Michigan.
"What Institutions Can Do—"	Professor James O. Smith, University of Illinois.

The main objective of each session was the accumulation of constructive ideas for transmission to the various committees of the ASEE having an interest in specific areas of development.

Professor W. Leighton Collins, Secretary of the ASEE, in a Greeting to the Conference, expressed the desire of ASEE officers to see more "grass roots" participation in Society activities. The Conference Committee felt strongly that the conference objective of stimulating ideas, criticisms and concrete suggestions and the subsequent transmittal of such ideas to officers of ASEE can constitute a major constructive contribution to "grass roots" participation.

The closing address of the Y.E.T. Conference, "Some Thoughts for the Y.E.T. during his First Five Years of Professional Development," by Clarence H. Linder, Vice President-Engineering, General Electric Corporation, was the opening event of the North-Midwest Section, ASEE Annual Meeting.

Respectfully,

JAMES D. HORGAN
THOMAS I. LYON
EDWARD P. MIKOL,
C.Y.E.T. Conference Committee, 1958,
North-Midwest Section

A STUDY OF THE PURDUE UNIVERSITY ENGINEERING GRADUATE [1]

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Introduction

Science can evaluate its accomplishments, at least in part, by new discoveries and innovations. Industry can measure success by comparing its production rates and costs with net profits. Some individuals think of success in terms of material gain, others by social status, and still others by intellectual accomplishments. Educational institutions find it more difficult to make an evaluation since information regarding their product—the graduate—is often lacking in any great detail. Because of this limit on information, a study was conducted among the engineering graduates of Purdue University who were awarded B.S. degrees from 1911 to 1956, inclusive. The study data included these major subject areas: precollege backgrounds, college experiences, postcollege experiences, and current opinions on a variety of subjects ranging from high school preparation to the goals of a college education.[2] In addition, a comparative study was made of the opinions expressed by the alumni, faculty and students on engineering curricula and education objectives, both of a general and specific nature.[3]

A summary of the four populations —alumni, faculty, senior students, and freshman students—is reported in Table I. Because of the intense interest in the postcollege activities of alumni, it would be helpful to describe that group in a more definitive manner. Table II reports the alumni group in terms of specific engineering degrees and by year of graduation.

The data for analysis were obtained through a mail type questionnaire. The basic questionnaire sent to the alumni contained 49 questions, essentially of a multiple response nature. In all, 1,204 alternatives were provided, with the minimum number of responses totalling 204. Since some of the questions directed to the alumni were not applicable to the faculty and students, questionnaire forms to the latter were reduced in size. To expedite the analyses, the respondents were requested to report their answers on a deck of mark-sense type IBM

[1] This research was sponsored by the Purdue University Engineering Experiment Station. An Experiment Station bulletin is in preparation and will be published in the Fall, 1959.

[2] These portions of the study were used to prepare an unpublished doctoral thesis entitled: "A Study of the Purdue University Engineering Graduate," submitted to the faculty of the University of Illinois, June, 1958, by Edward C. Thoma.

[3] This portion was used to prepare an unpublished doctoral thesis entitled: "The Attitudes of Purdue Alumni, Faculty, and Students Toward the Goals of General Education," submitted to the faculty of Purdue University, May, 1958, by John Gillis.

TABLE I

THE POPULATION SIZES, SAMPLE POPULATIONS AND RETURNS FOR THE ALUMNI, FACULTY, SENIOR STUDENTS AND FRESHMAN STUDENTS IN THE PURDUE UNIVERSITY STUDY

Population	Total Population Size	Study Sample Size		Returns in the Study		
	No.	No.	%	No.	% of Sample	% of Total
Engineering alumni (1911–1956)	24,294	5,429	22.3	3,799	70.0	15.6
Engineering faculty (1957)	330	288	87.4	173	60.0	52.5
Engineering senior students (1957)	1,313	384	29.2	217	56.6	16.5
Engineering freshman students (1957)	2,355	378	16.1	246	65.1	10.4

cards. In order to retain anonymity among the individual responses a code number was keyed into the return-data deck. In addition to the confidential aspect the coding provided several other advantages: (1) follow-up procedures were made with minimum expense; (2) scholarship data could be collected for the alumni; and (3) characteristics peculiar to the no-response group could be identified so that any serious limitations in the data would be noted.

The Engineering Alumni

All data regarding the alumni were analyzed, as a minimum, in four ways: (1) by engineering degree; (2) by year of graduation; (3) by current job function; and (4) by scholastic rank at graduation.[4]

Age at Graduation. The average age at graduation for all alumni reporting was 23.1 years. Little difference was noted among the alumni by area of degree. The World War II period revealed two differences. The graduates during the war years (1941–45) were 1.2 years younger than the average for all graduates. In contrast the group which graduated immediately after the War (1946–50) was 1.4 years older than the average. According to job function those who engaged in graduate study were 1.3 years younger than the average. The alumni who ranked in the lowest scholarship decile were 1.7 years older than the alumni who ranked in the highest decile.

Semesters Required To Graduate. Approximately 70% of the alumni received their degree in eight semesters. Prior to 1935 about 88% received a degree in the usual four-year time period. Since 1935, the average has been slightly less than 70%. According to job function alumni engaged in teaching and graduate study were more apt to graduate in four years than alumni reporting in the other functions. Approximately 85% of the alumni who placed in the upper half of their class scholastically graduated in four years. In contrast, those in the lower half ranged from 25% for those who placed in the lowest 10% to 74% for those in the 40–49 percentile group.

College Expenses Earned. The alumni who submitted data on earned college expenses reported as follows: none–23%, ¼–38%, ½–20%, ¾–11%, all–7%. The alumni who were more apt to earn some or all of their college expenses received degrees in agricultural engineering, engineering law and engineering mechanics. Prior to 1936 approximately 12% of the alumni earned all of their way through col-

[4] Scholarship rankings were obtained for 1351 alumni who graduated between 1931 and 1946.

TABLE II

COMPARISON OF THE ENGINEERING DEGREES AWARDED BY PURDUE UNIVERSITY BY AREA AND YEAR WITH THE SAMPLE USED IN THIS STUDY

Engineering Degree

Degree	Total Engineering Graduates		Study Sample		Returns in Study	
	No.	%	No.	%	No.	%
Aeronautical	986	4.1	259	4.8	170	4.5
Agricultural	226	0.9	68	1.3	55	1.4
Chemical	3,306	13.6	763	14.1	543	14.3
Civil	3,440	14.2	814	15.0	554	14.6
Electrical	6,117	25.2	1,347	24.8	959	25.2
Engrg. Law	57	0.2	19	0.3	14	0.4
Engrg. Mech.	71	0.3	34	0.6	29	0.8
Mechanical	9,362	38.5	1,901	35.0	1,296	34.1
Metallurgical	560	2.3	172	3.2	135	3.5
Other	169	0.7	52	0.9	45	1.2
Totals	24,294	100.0	5,429	100.0	3,799	100.0

Year of Graduation

Year of Graduation	Total Engineering Graduates		Study Sample		Returns in Study	
	No.	%	No.	%	No.	%
1911–15	952	3.9	196	3.6	92	2.4
1916–20	730	3.0	179	3.3	113	3.0
1921–25	1,422	5.9	306	5.6	192	5.1
1926–30	1,515	6.2	332	6.1	226	5.9
1931–35	2,092	8.6	481	8.9	344	9.1
1936–40	2,299	9.5	532	9.8	364	9.6
1941–45	2,619	10.8	699	12.9	494	13.0
1946–50	6,252	25.7	1,369	25.2	1,001	26.3
1951–55	4,596	18.9	1,088	20.0	810	21.3
1956	1,817	7.5	247	4.6	163	4.3
Totals	24,294	100.0	5,429	100.0	3,799	100.0

lege. Since 1936 only 5% earned their entire way. There was very little difference in college expenses earned by individuals over the entire scholarship continuum.

College Housing Accommodations. The survey made no specific attempt to determine the marital status of the alumni while attending college; however, the increasing number of the more recent graduates who reported that they lived in family housing suggests that it is becoming more common for college students to be married. Since 1946, 15% of the alumni reported that they lived in private apartments and university family housing. Prior to 1946 only 2% were in that type of housing.

Among the other students between 1946 and 1956 an equal percentage lived in dormitories and fraternities. That percentage was twice that reported for private homes. The schol-

arship data indicated that, among the three major types of housing for the single student—dormitory, fraternity and private home—the university dormitory group had the best scholastic average. Whereas 12% of those residing in dormitories were in the lower fifth of their class scholastically, the fraternities and private homes had 24 and 22%, respectively. Twenty-nine per cent of the dormitory students were in the upper fifth of their class; the fraternity and private home students were 21 and 24%, respectively.

Rating of High School Preparation. The alumni were asked to rate the adequacy of their high school preparation in four subject areas: mathematics, English, chemistry and physics.

1. Mathematics: Agricultural engineering alumni were more apt to feel less satisfied with their preparation in mathematics than graduates in the other degree areas. Ninety per cent or more of the alumni with aeronautical, chemical, engineering law, engineering mechanics, and metallurgical degrees felt that their high school mathematics adequately prepared them for college study. The degree of satisfaction with mathematics was positively related with scholastic ranking and ranged from 81.7% for those in the lowest decile to 95.3% in the highest decile.

2. English: Agricultural engineering alumni reported the lowest rating (74.6%) and chemical engineering alumni reported the highest rating (88.1%). The difference among alumni according to the engineering degree awarded was significant. Analysis by year of graduation, job function and scholarship showed no significant difference in opinion about the adequacy of high school English preparation.

3. Physics: Engineering law and agricultural engineering alumni were more dissatisfied with their high school physics preparation than the other engineering graduates. The most satisfied were the engineering mechanics alumni. The difference by degree was significant. Because the more recent graduates were less satisfied with their high school physics preparation, the difference among the alumni according to their year of graduation was significant. In general, the higher the college academic standing of the alumni the more apt they were to express a greater satisfaction with their high school preparation in physics.

4. Chemistry: Opinions concerning the adequacy of chemistry preparation were significantly different when analyzed by degree and year of graduation. The chemical and metallurgical engineering alumni expressed the highest degree of satisfaction and engineering alumni the lowest degree of satisfaction. The differences by year of graduation were significant principally because of a higher than average satisfaction expressed by the graduates between 1936 and 1945.

In summary it should be noted that the question asked for an expression of opinion and may or may not represent any real difference in either a relative or absolute sense; i.e., content, amount of preparation, depth of study, standards and so on.

Extracurricular Activity Participation. Drama, debate, student government, musical organizations, and varsity athletics showed a decrease in the percentage of participation over the 46 year time span. These decreases may be due, in part, to the limited number of positions in these activities regardless of the size of an institution. Specific activities which showed an increase over the 46 year period were intramural sports, student professional societies and housing organizations. Participation in religious organizations and scholastic honor societies was fairly constant. The oldest graduates (1911–15) reported the highest re-

sponse (22%) to the "no" participation response. Only 10% of the recent graduates reported that they did not participate in extracurricular activities. This difference might be attributed to a greater number of activities or to a greater emphasis on activity participation.

Postgraduate Work. Fifty per cent of the alumni who responded reported that they did some college work beyond the bachelor's degree either by formal enrollment in a graduate plan of study or by some informal procedure. Of the 23.4% who formally enrolled 60.7% (14.1% to the total alumni group) received a master's degree or higher. The degree areas from which alumni were more apt to continue formal graduate study included engineering mechanics, and chemical, metallurgical and aeronautical engineering. Alumni throughout the scholarship continuum enrolled in formal graduate programs; however, 50% of the alumni in the highest decile attended compared to 10% in the lowest decile.

About 1.6% of the alumni received a doctor's degree in either engineering or the physical sciences. The majority of these degrees were earned by those who ranked in the top 10% of their class.

Job Placement. Since World War II over 50% of the Purdue University alumni obtained their initial postcollege position through the University's Placement Service. Those who ranked high in scholarship between 1931 and 1946 obtained initial employment through the Service at twice the rate reported by alumni who ranked in the lowest third. Only 6% of the alumni sought the help of the Placement Service for subsequent jobs.

Twenty-five per cent of the alumni with twenty-five to thirty years of job experience had only one employer since graduation. Over 50% of the graduates since the class of 1916 reported that they had had no more than three employers.

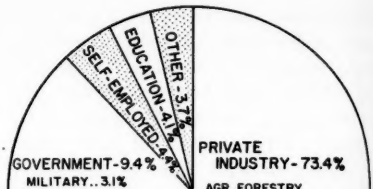


FIG. 1. Major Fields of Employment of the Purdue University Engineering Alumni.

Fields of Employment. The employment of most Purdue engineering alumni could be classified in five major categories: private industry, private engineering practice, government, self-employed (non-engineering), and educational institutions. These data are shown in summary form in Figure 1. The degree areas which differed most from the average values given in Figure 1 were aeronautical, agricultural and civil. Only 50% of the civil engineers were employed by private industry. About 20% of the aeronautical and civil alumni reported that they worked for some governmental agency. About 9% of the agricultural engineering alumni, or twice as many as from any of the other degree areas, were self-employed in non-engineering work. A summary of fields of employment by degree area is reported in Table III. Of the 3,799 alumni who participated in the study, 88% reported that they were currently employed in some type of engineering work.

Employment was reported, also, according to a specific function. Sixteen defined job functions were regrouped into five major categories: pre-profes-

TABLE III

PERCENTAGE DISTRIBUTION OF PURDUE ENGINEERING ALUMNI, BY AREA OF DEGREE AND MAJOR FIELDS OF EMPLOYMENT

	Aero.	Agr.	Chem.	Civil	Elec.	Engrg. Law	Engrg. Mech.	Mech.	Met.
Private Industry:	66.0	65.0	77.5	50.6	79.6	85.8	72.7	76.2	87.6
Agr., Forestry, Fishery		5.3	0.4	0.8	0.5			0.4	
Finance, Real Estate, Insurance			0.9	0.8	0.6			0.9	
Construction	1.2	7.0	0.2	18.2	1.7		3.0	2.6	
Manufacturing	61.8	47.5	69.4	19.1	55.0	57.2	66.7	64.1	84.7
Aircraft	*48.2*	*3.5*	*1.6*	*3.1*	*6.6*	*7.1*	*33.4*	*10.3*	*11.8*
Automotive	*2.9*	*1.8*	*1.8*	*0.8*	*2.5*		*6.1*	*8.8*	*8.1*
Chemical		*1.8*	*34.8*	*2.4*	*1.7*	*7.1*		*3.8*	*2.2*
Electrical equipment	*1.8*	*1.8*	*3.4*	*0.8*	*32.3*	*14.3*	*3.0*	*6.2*	*7.4*
Food		*1.8*	*1.5*	*0.2*	*0.3*	*7.2*		*1.5*	
Materials	*1.2*		*8.8*	*3.3*	*1.4*		*3.0*	*4.4*	*24.2*
Mechanical equipment	*1.8*	*29.8*	*5.2*	*4.1*	*3.5*	*7.2*	*12.1*	*18.6*	*7.4*
Other	*5.9*	*7.0*	*12.4*	*4.4*	*6.7*		*9.1*	*10.5*	*23.6*
Public Utilities	1.2	3.5		8.4	18.0	14.3	3.0	4.5	
Transportation	*0.6*		*0.2*	*4.2*	*1.1*		*3.0*	*1.1*	
Communications	*0.6*			*1.2*	*6.8*	*14.3*		*0.7*	
Services (gas, light)		*3.5*	*2.7*	*1.5*	*10.0*			*2.3*	
Services (sanitary, water)			*0.9*	*1.5*	*0.1*			*0.4*	
Services	1.8	1.7	2.7	3.3	3.8	28.6		3.7	2.9
Medical, legal professions				*0.3*	*0.5*	*28.6*		*0.4*	*0.7*
Social	*0.6*	*1.7*							
Wholesale & retail trades	*0.6*		*1.4*	*1.5*	*1.6*			*2.1*	*2.2*
Other	*0.6*		*1.3*	*1.5*	*1.7*			*1.2*	
Private Engrg. Practice:	2.3	3.5	2.4	15.2	3.0			4.0	1.5
Owner/Partner	0.5		0.9	6.9	2.0			1.7	
Employee	1.8	3.5	1.5	8.3	1.0			2.3	1.5
Government:	21.2	10.6	5.5	21.1	7.0	14.2	6.0	6.8	3.6
Federal	21.2	10.6	5.5	9.2	6.6	14.2	3.0	6.6	3.6
Armed Services	*16.5*	*5.3*	*4.4*	*6.8*	*6.6*	*14.2*	*3.0*	*6.6*	*3.6*
Civilian	*4.7*		*1.5*	*3.7*	*3.0*	*7.1*		*3.4*	*0.7*
Military	*11.8*	*5.3*	*2.9*	*3.1*	*2.4*	*7.1*	*3.0*	*2.5*	*2.9*
Agency	*4.7*	*5.3*	*1.1*	*2.4*	*1.2*			*0.7*	
State				7.5	0.3		3.0	0.1	
Local				4.6	0.1			0.1	
Self-Employed (Non engrg.):	3.5	8.7	3.9	4.6	3.1			5.7	2.2
Small Business	2.3	1.7	2.5	3.3	1.8			4.1	1.5
Other	1.2	7.0	1.4	1.3	1.3			1.6	0.7
Educational Institutions:	4.7	6.9	6.2	4.6	3.2		18.2	4.1	2.2
Primary Schools					0.1			0.1	
Secondary School			0.2	0.3	0.3			0.4	
College	4.7	6.9	6.0	4.3	2.8		18.2	3.6	2.2
Student	*0.6*	*1.7*	*2.2*	*0.3*	*0.3*		*9.1*	*0.7*	*0.7*
Teacher	*1.2*	*3.5*	*2.9*	*1.6*	*1.0*		*9.1*	*1.2*	*1.5*
Researcher	*3.3*	*1.7*	*0.5*	*1.3*	*1.0*			*1.0*	
Administrator	*0.6*		*0.4*	*1.1*	*0.5*			*0.7*	
Other:	2.3	5.3	4.5	3.9	4.1		3.1	3.2	2.9
Retired Status			1.8	2.3	1.5			1.1	
Housewife			0.7						
Other	2.3	5.3	2.0	1.6	2.6		3.1	2.1	2.9
Totals	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

sional, operations, new developments, human relations, and miscellaneous. These data are summarized in Figure 2. In order to evaluate trends in job function with both the time spent in job experience and changes in the employment picture, the job functions for the graduates in the different classes have been summarized at graduation, at 6–10 years after graduation, and at 21–25 years after graduation, in Figure 3. Since World War II, more and more of the alumni have been given job responsibilities in design, research and development (the new development functions) at graduation. This suggests that industry has placed engineering graduates in positions which take increasing advantage of their college training.

Professional Activities. The professional activities which were studied

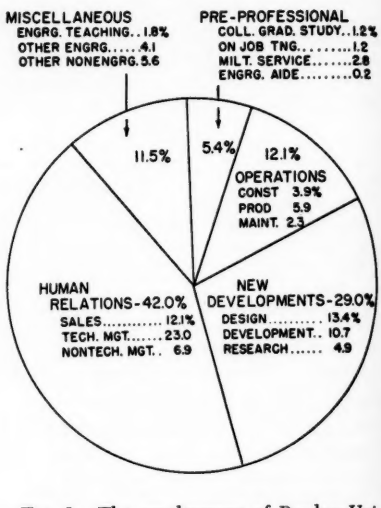
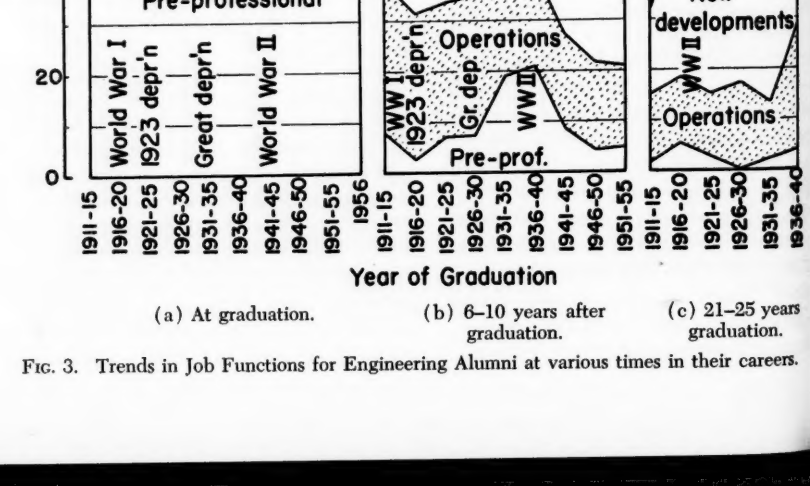


FIG. 2. The employment of Purdue University Engineering Alumni by Job Function.



(a) At graduation. (b) 6–10 years after graduation. (c) 21–25 years graduation.

FIG. 3. Trends in Job Functions for Engineering Alumni at various times in their careers.

included registration membership, professional society membership and professional society activities such as attendance and writing. Twenty-five per cent of the alumni were registered professional engineers; however, 50% of the civil engineering graduates reported that they were registered. Since 1946 there has been an increase in the percentage of alumni who were registered or reported that they held an in-training certificate. Alumni engaged in the job functions of construction engineer and engineering teacher reported a higher percentage of registration than any of the other functions. There was no difference in registration according to the scholastic rank of the alumni.

There was evidence of a consistent relationship between registration and professional society membership in all degree areas except metallurgical, chemical, aeronautical and engineering mechanics. Alumni with degrees in aeronautical, chemical and metallurgical engineering seemed to place a greater import on society membership than on registration. The converse of this was held by the engineering mechanics alumni. Although the total membership in professional societies has been increasing nationally, the percentage of Purdue engineering alumni who obtained membership has remained fairly constant throughout the 46 years covered by the study. That evidence suggests that perhaps the individual technical societies are growing only in numbers rather than reaching a greater percentage of the persons qualified for membership.

Similar to the finding about registration, the engineering teachers were more apt to be members of professional societies than alumni engaged in any of the other job functions. Only 37% of the alumni felt that society membership was a requisite for professional status. Twenty per cent reported that they had contributed technical articles for journal publication; however, only 4% reported that they regularly contributed articles.

The alumni who held society memberships indicated that they were relatively inactive in the societies the first five to six years after college graduation. Whereas 43% of the oldest graduates who were members of professional societies held or had held a local section office, only 13% of the alumni who were members but out of college for less than sixteen years held or had held a local section office.

Professional Attainment. It is difficult to evaluate *success* since individuals may have different criteria, all of which may be valid according to their own value system. However, in order to tackle this question a criterion containing three measures was arbitrarily established. These measures were patents, job position, and salary.

1. Patents. The patent question requested a report on the number of patents for which the alumni had applied, irrespective of whether or not any patent had been granted.

According to degree area the most creative alumni were chemical, electrical, mechanical engineering, and engineering mechanics graduates. The least creative were the civil engineering and engineeering law alumni. An increasing percentage of alumni applied for patents during the first fifteen years following graduation. After that time the total percentage of alumni granted or making application for patents held constant. That seemed to suggest that the younger years were the more productive in the creative talents. When comparing patents with present job functions, the most creative alumni were those engaged in the development, research and technical management functions. The least creative were those engaged in the maintenance and construction

functions.[5] Scholarship seemed to make a difference in creativeness if patents served as the criterion. Forty per cent of those in the upper fifth reported one or more patents versus 27% for those in the lower four-fifths. In the lower group, alumni who reported that they had applied for or had been granted a patent usually had but one patent if they ranked in the lowest decile. If they ranked higher up the scholarship ladder, they were more apt to report two or more patents.

2. Level of Job Position. The alumni were asked to select one of the eleven job titles which best identified their duties and responsibilities. The job titles were draftsman, assistant cartographer, assistant field engineer, design engineer, project engineer, assistant superintendent, district engineer, assistant chief engineer, chief engineer, vice-president, and president. It is important to note that the difference between any two successive position is not necessarily equal. Furthermore, it must be recognized that some of the lower positions have a far greater number of openings than the higher positions.

The median job position for alumni with less than one year experience was design engineer. At the end of twenty-five years experience the median job level was assistant chief engineer. Twenty-five per cent of the alumni with twenty or more years of experience reported that they held a job position with responsibilities equivalent to or higher than that of chief engineer. Scholarship and job level comparisons showed significant differences between the lowest and highest scholarship deciles. The median job level for those in the lowest 10% was two positions below that reported by their contemporaries who ranked in the highest 10% scholastically (project engineer vs. district engineer).

3. Salary. Salaries were investigated in two ways. First, the respondents were asked to mark their current monthly salary in one hundred dollar increments and second, they were asked to mark their yearly salary for as many as nine levels of job experience.

Current median salary was related to year of graduation for alumni with twenty years experience or less. The current median salary for alumni with more than twenty years experience was fairly stable at approximately $1,000 a month. Alumni who reported salaries of less than the median indicated that they received substantial increases for only fifteen years as contrasted with twenty years for those at the median. The highest rate of salary increase was reported by the alumni who received salaries at the upper quartile (top 25%). Their current monthly salary at twenty years was $1,290.

Although there was considerable overlap of salary when comparisons were made with scholastic rank, scholarship and salary were positively related. For example, 25% of the top decile in scholarship reported current monthly salaries of $1,300 or more. In contrast only 9% of the lowest decile reported similar salaries.

The median annual salaries for the several groups of graduating classes are summarized in Table IV at different levels of experience. Evidence throughout the study suggests that the individual alumnus required approximately fifteen to twenty years to establish his level of success. Data for salary and job position title showed positive correlation and each indicated that the engineering alumnus could

[5] The authors do not wish to imply that a patent is the only criterion for creativeness. They fully recognize that many designs and discoveries are not patentable. Also, many construction and maintenance engineers are extremely ingenious in accomplishing their job.

TABLE IV

MEDIAN ANNUAL SALARY IN DOLLARS

Year of Graduation	Years After Graduation							
	1–2	3–5	6–10	11–15	16–20	21–25	26–30	31 up
1911–15	1,269	2,096	3,250	4,162	4,862	5,973	7,678	10,210
1916–20	1,670	2,585	3,614	4,130	5,045	6,798	8,833	11,800
1921–25	1,855	2,727	3,384	4,220	5,520	7,183	9,543	12,820
1926–30	1,744	2,232	2,861	4,576	6,940	9,245	12,450	
1931–35	1,409	2,304	3,674	5,833	8,423	11,485		
1936–40	1,774	2,933	5,148	7,918	11,230			
1941–45	2,688	4,052	5,159	9,543				
1946–50	3,966	5,995	8,483					
1951–54	4,320	6,313						
1956	5,595							

use the time criterion of fifteen to twenty years to predict his future rate of success.

Salaries were compared, also, to the level of education achieved by the graduate; i.e., bachelor's, or doctor's degree. Alumni who continued their formal education to the doctorate level reported higher salaries at the lower quartile and median salary points if the bachelor's degree was received prior to 1940. This was true, also, at the upper quartile salary point, but only for those almuni who received their bachelor's degree since 1941. Insofar as the master's degree was concerned, a higher level of educational achievement had little or no relation to the future earning power of the alumni. In many instances alumni who terminated their education at the bachelor's level reported salaries equal to or better than their contemporaries who continued college work at the master's level.

In order to obtain a more complete description about how Purdue engineers compare at several points on the salary continuum, the data of Table IV have been expanded in Table V to include data at the lower decile, lower quartile, upper quartile, and upper decile. It will be noted that salaries at the median or below reach their peak at twenty years after gradution. The peak at the upper quartile and upper decile was reached in thirty years. It is significant to note that 50% of the graduates with twenty-six to thirty years' experience reported an annual salary in excess of $12,000. It will be noted, also, that 10% with more than twenty-two years' experience received a salary in excess of $24,890 annually.

Career Satisfaction. Eighty-five per cent of the alumni indicated that they were satisfied with their career since graduation. Approximately 10% were neutral while 5% expressed some

TABLE V

CURRENT ANNUAL SALARIES BY YEAR OF GRADUATION AT SEVERAL DEFINE POINTS IN THE SALARY CONTINUUM (1957)

Year of Graduation	1911–15	1916–20	1921–25	1936–30	1931–35	1936–40	1941–45	1946–50	1951–55	1956
Lower decile	$ 4,750	$ 2,600	$ 4,800	$ 6,905	$ 6,250	$ 6,602	$ 5,922	$ 5,280	$ 4,734	$ 709
Lower q'tile	6,792	8,010	8,592	8,802	8,528	7,565	7,880	6,850	6,025	3,572
Median	10,210	11,800	12,820	12,450	11,485	11,230	9,543	8,483	7,715	5,595
Upper q'tile	22,250	19,040	20,890	22,100	14,880	14,670	12,635	9,792	9,150	6,655
Upper decile	41,350	25,000	37,875	42,575	24,890	22,440	14,820	13,105	10,105	7,280

measure of dissatisfaction with their career. Insofar as their choice of undergraduate engineering curriculum was concerned, 90% expressed satisfaction, 5% were neutral, and 2% were dissatisfied.

An Ideal Engineering Curriculum. The alumni were asked to select from a list of six defined curricula the one which they felt would best serve the requirements of engineering. A five-year or six-year co-operative curriculum was favored by the chemical, civil, electrical, mechanical, and metallurgical engineering alumni. The aeronautical engineering alumni favored a five-year curriculum which placed a greater emphasis on scientific subjects. The agricultural and engineering mechanics alumni selected a four-year curriculum which emphasized a more thorough scientific training through a de-emphasis of field specialization.

Educational Values: Alumni, Faculty and Students

The frame of reference for this phase of the study was based largely upon the recommendations of committees with national scope regarding the goals and content of higher education. The President's Commission on Higher Education [6] reported on the general education goals and Kidd and Associates [7] expanded the general goals to include specialized goals of a vocational nature. The goals and curricula content with particular reference to engineering education were studied on the basis of the recommendations of three committees operating under the auspices of ASEE; i.e., the Hammond,[8] Grinter [9] and Burdell-Gullette [10] committees. This Purdue University study secured the attitudes from alumni, engineering faculty members and senior and freshman students.

Engineering Curricula

In order to determine the relative importance which the populations placed on the inclusion of various technical and nontechnical subjects in the engineering curricula, they were asked to respond on the subjects in one of four ways: "A Must Requirement," "Very Important," "Moderately Important," and "Little or No Importance." The responses (by percentage) for the four groups are summarized in Table VI.[11] The listing in the table is according to the percentage of the alumni population who marked the "Must" and "Very Important" responses. Response patterns which were significantly different at the .001 level between the four sample populations are indicated by an asterisk to the right of the percentage columns.

It was interesting to note the near unanimity with regard to the importance of English composition, speech, engineering materials, and engineering laboratories. Apparently only a small minority felt that history, English literature, foreign language and

[6] President's Commission on Higher Education, *Higher Education for American Democrary.* Harper & Bros. no date, p. 50.

[7] Kidd, J. W., and others, "Student Attitudes Toward General Education," *Journal of Higher Education,* **25**, 209–213, April, 1954.

[8] Hammond, J. R., and others, "Report of the Committee on Aims and Scope of Engineering Curricula," *Journal of Engineering Education,* **30**, 555–556, March, 1940.

[9] Grinter, L. E., and others, "Final Report on Evaluation of Engineering Education," *Journal of Engineering Education,* **46**, 26–60, September, 1955.

[10] Burdell, E. S., Gullette, G. A., and others, "General Education in Engineering—A report of the Committee for the Humanistic-Social Research Project," *Journal of Engineering Education,* **46**, 619–750, April, 1956.

[11] The sixteen technical subjects and the twelve nontechnical subjects are indicated by the abbreviations TS and NTS, respectively.

TABLE VI

PERCENTAGE OF ALUMNI, FACULTY, SENIORS AND FRESHMEN WHO EVALUATED THE TECHNICAL AND NONTECHNICAL SUBJECTS AS "MUST" OR "VERY IMPORTANT" CURRICULA REQUIREMENTS

	Importance			
	Al	Fa	Sr	Fr
1. English Composition (NTS-2)	92	95	94	86
2. Speech (NTS-1)	88	81	77	81*
3. Engineering Science—Properties of materials (TS-15)	85	87	78	85
4. Engineering Laboratories (TS-4)	82	76	61	88*
5. Specialty engineering courses (TS-10)	79	78	88	83
6. Engineering Science—Mechanics of Solids (TS-11)	78	82	70	79
7. Engineering Science—Electrical theory (TS-14)	78	76	67	74
8. Engineering Drawing and Graphics (TS-6)	78	55	61	83*
9. Service Courses (TS-9)	75	72	61	62*
10. Engineering Science—Fluid mechanics (TS-12)	74	82	76	70
11. Engineering Science—Thermodynamics (TS-13)	73	82	74	80
12. Business Industrial Management (NTS-4)	72	36	51	58*
13. Engineering Science—heat-mass and momentum transfer (TS-16)	72	78	66	79
14. Engineering Economics (TS-3)	66	53	48	61*
15. Shop Courses (TS-5)	62	17	27	55*
16. Economics (NTS-5)	61	68	48	42*
17. Physics beyond one year (TS-8)	53	70	46	76*
18. Psychology (NTS-11)	47	29	38	37*
19. Math beyond calculus (TS-1)	43	86	76	89*
20. Government (NTS-7)	35	41	40	32
21. Chemistry beyond one year (TS-7)	34	30	20	56*
22. Math beyond diff. equations (TS-2)	26	51	38	83*
23. Religion (NTS-12)	21	14	14	33*
24. Philosophy (NTS-10)	20	22	22	14
25. History (NTS-8)	19	31	31	19*
26. English Literature (NTS-3)	16	29	27	17*
27. Foreign Language (NTS-6)	8	22	13	12
28. Fine Arts (NTS-9)	6	7	9	7

* Chi Square values (based on frequencies) significant at .001 level.

fine arts were "Very Important." A significantly higher percentage of the faculty stressed the importance of foreign language, history, English literature and additional mathematics and physics. Proportionally, fewer engineering faculty members felt that engineering drawing and graphics, shop courses, business and industrial management, and psychology were "Very Important" or "A Must Requirement" when compared with alumni and students.

Engineering Education Goals

In the Hammond Report the objectives of engineering education were divided into two major classifications: scientific-technological and social-humanistic goals. The latter goals were reaffirmed as highly desirable by Burdell, Gullette and colleagues. These same goals were stressed by Grinter and his colleagues under the identification of "technical and social objectives." Many of the objectives in the above mentioned reports were quite lengthy and, in reality, included a multiple number of specific goals. Therefore, objectives which included sub-parts were divided and analyzed as separate and distinct goals. The goals were evaluated in two ways: 1. *Importance "How important is this as an educational goal?"* with four response categories: "Very Important,"

TABLE VII

PERCENTAGE OF ALUMNI, FACULTY, SENIORS AND FRESHMEN WHO EVALUATED THE ENGINEERING EDUCATION GOALS AS VERY IMPORTANT AND INDICATED MUCH OR SOME ACHIEVEMENT

	Importance				Achievement			
	Al	Fa	Sr	Fr	Al	Fa	Sr	Fr
1. Ability to think straight in the application of fundamental principles to new problems (T–8)	95	96	98	91	88	52	84	97*
2. Ability to organize thought logically (H–3)	94	89	96	86*	87	70	85	97*
3. Mastery of fundamental scientific principles (T–1)	92	96	93	90	97	84	95	99*
4. Ability to present significant results in a study clearly in oral and written forms (T–14)	90	89	87	75*	81	61	82	97*
5. Ability to express thoughts lucidly and convincingly in oral and written English (H–5)	90	83	88	77*	74	50	77	96*
6. Grasp the meaning of physical and mathematical laws (T–3)	82	89	81	82	94	67	87	97*
7. A foundation for engineering judgment (T–11)	81	65	78	66*	87	55	74	90*
8. Thorough understanding of the engineering method and elementary competence in the application of the engineering method (T–5)	78	70	72	67*	90	64	71	92*
9. Ability to read with discrimination and purpose (H–4)	76	78	75	70	60	48	64	95*
10. Resourcefulness and originality in devising means to an end (T–12)	75	63	70	65*	65	42	56	87*
11. Command of basic knowledge of branches of engineering (T–2)	71	58	58	52*	96	76	86	93*
12. Understanding the element of cost in engineering and ability to deal with the element of cost just as competently as with technological factors (T–13)	68	46	58	60*	42	38	45	88*
13. Reasonable skill in choosing the type of approach in light of the time available for solution (T–10)	66	43	61	63*	65	42	62	89*
14. Comprehending interacting elements in situations which are to be analyzed (T–7)	64	63	70	44*	72	39	71	87*
15. Development of moral, ethical, and social concepts essential to a career and consistent with the public welfare, to a satisfying personal philosophy, and to a sound professional attitude (H–7)	63	66	64	56	56	52	50	86*
16. Reasonable skill in making approximations (T–9)	56	51	50	49	75	52	78	92*
17. Knowledge of how physical laws evolve and the limitations of their use (T–4)	54	58	58	44	83	37	78	90*
18. Stimulation of a continued interest in further professional development (T–15)	49	77	61	52*	63	63	59	88*
19. Knowledge of materials, machines, and structures (T–6)	48	39	35	53*	84	69	73	92*
20. Ability to recognize, make a critical analysis of, and arrive at an intelligent opinion about a problem involving social and economic elements (H–2)	41	32	40	34	38	35	44	77*
21. Understanding the evolution of the social organization in which we live and the influence of science and engineering on its development (H–1)	28	32	24	20	40	39	47	73*
22. Attainment of an interest and pleasure in social-humanistic pursuits and, thus, an inspiration to continue study in this area (H–8)	20	19	23	26	33	29	34	68*
23. Acquaintance with some of the masterpieces of literature, and an understanding of literature's setting and influence on civilization (H–6)	8	10	10	6	32	23	37	51*

* Chi Square values (based on frequency) significant at .001 level.

The symbols T–1 through T–15 and H–1 through H–8 are the scientific-technological and social-humanistic goals, respectively, as defined in the Hammond Report.

"Some Importance," "Little Importance," and "No Importance"; 2. *Achievement* "*How much did your undergraduate training help toward attaining it?*" with four response categories: "Much," "Some," "Little," and "None."

The importance stimulus for all groups was essentially the same. However, the achievement response for freshman students and faculty members differed in that freshmen were asked to indicate the extent to which they *expected* to attain the goals and faculty members were asked to indicate the extent to which they felt *students in their area of teaching* had achieved the goals. The results are summarized in Table VII. The goals are listed in order of importance according to the percentage of alumni who marked the "Very Important" response. The faculty, and senior and freshman student responses are also reported in percentages. The percentages listed in the achievement columns represent the alumni, faculty, and senior and freshman student responses for the "Much" and "Some" categories. Differences in the proportions of alumni, faculty, senior and freshman samples which resulted in significant chi square values (.001 level) are again noted by an asterisk.

It will be noted that there was almost universal agreement on the importance of goals that stressed logical thinking, oral and written communications, and an understanding of fundamental scientific and engineering principles. Less than one in three of the alumni, faculty and student populations felt that the goals stressing the understanding of our social organization or the pursual of social-humanistic subjects such as literary and fine arts interests were "Very Important" goals in an engineering education.

Engineering faculty members were more apt to stress the importance of interest in professional development than the alumni and students. However, the faculty were less apt to stress the importance of skill in problem solution and the understanding of cost in engineering. Alumni were more apt to stress the importance of oral and written communications and the command of branch engineering than the other groups.

With regard to achievement, the freshmen were perhaps the most optimistic. The faculty, in general, were the most pessimistic. This, perhaps, may be more a reflection of the response set than actual differences, since the freshmen indicated the extent to which they *expected* to attain the various goals whereas the faculty indicated the extent to which they felt that *students in their area* attained the various goals. Expectation was not the basis for the alumni and senior student responses; these groups were asked to indicate the extent to which they felt they had *achieved* the goals.

General and Specialized Education Goals

The President's Committee on Higher Education, 1947, attempted to outline the general educational goals of colleges and universities regardless of curricula. Kidd and his associates used these same goals as well as a number of specialized goals. The principal focus of attention in the Kidd study was on attitudes and, therefore, was very similar to this Purdue study in that respect. The general and specialized educational goals were evaluated in the same way as the engineering goals except that the frame of reference was college in general rather than a specific college curriculum. As for the engineering education goals the response categories for importance were "Very Important," "Some Importance," "Little Importance" and "No Importance." The achievement responses were "Much," "Some," "Little," and "None."

TABLE VIII

PERCENTAGE OF ALUMNI, FACULTY, SENIORS AND FRESHMEN WHO EVALUATED THE GENERAL AND SPECIFIC GOALS OF A COLLEGE EDUCATION AS VERY IMPORTANT AND INDICATED MUCH OR SOME ACHIEVEMENT

	Importance				Achievement			
	Al	Fa	Sr	Fr	Al	Fa	Sr	Fr
1. Ability to express one's thoughts effectively (G–10)	93	89	89	86*	80	64	80	97*
2. Ability to acquire and use the skills and habits involved in critical and constructive thinking (G–3)	87	87	86	80*	83	65	80	95*
3. Ability to learn to get along with people (G–5)	86	61	79	88*	75	84	78	94*
4. Ability to understand the ideas of others (G–6)	79	74	75	74	78	78	76	94*
5. Ability to develop knowledge and understanding in making possible a more effective choice of one's life work (G–4)	70	56	74	79*	59	58	57	96*
6. Ability to become proficient in one's chosen field of work (S–6)	68	63	71	91*	86	70	82	96*
7. Ability to attain emotional and social adjustment (G–16)	67	51	69	78*	65	68	65	92*
8. Ability to develop a code of behavior based on democratic and ethical principles (G–11)	66	59	56	62	69	60	58	86*
9. Ability to experience a realistic sampling of one's chosen profession (S–1)	61	46	62	64*	60	62	55	92*
10. Ability to move smoothly from adolescent dependence to adult independence (G–15)	57	47	59	73*	63	66	63	92*
11. Ability to habitually apply scientific thought to the discovery of facts (G–8)	53	62	48	60	80	50	76	93*
12. Ability to acquire knowledge and attitudes basic to a satisfying family life (G–9)	52	38	43	64*	36	46	33	79*
13. Ability to master certain techniques applicable to one's vocational field or special interest (S–2)	51	43	60	69*	80	81	82	95*
14. Ability to develop a broad general outlook and familiarity with a variety of subjects (G–7)	51	30	51	52*	69	53	77	86*
15. Ability to maintain and improve one's own health (G–1)	49	51	44	67*	41	59	30	78*
16. Ability to know the major developments in a field of vocational or special interest (S–10)	49	46	53	65*	72	69	69	94*
17. Ability to bring up to date one's knowledge in a special field of interest or a vocational field (S–9)	37	33	51	68*	67	62	67	92*
18. Ability to understand one's physical and social environment (G–13)	36	36	41	43	54	60	61	83*
19. Ability to acquire specific information and techniques in preparation for further study in a particular field (S–7)	33	37	41	60*	72	72	77	95*
20. Ability to acquire a degree of expertness in a special field (S–8)	30	28	38	67*	66	58	61	94*
21. Ability to recognize the fact of world interdependence (G–2)	29	41	35	41*	35	48	43	73*
22. Ability to develop the ability to do independent research (S–4)	26	24	36	60*	51	27	42	92*
23. Ability to master a classification of knowledge in a field (S–5)	25	24	33	55*	67	46	63	91*
24. Ability to develop certain manual skills (S–3)	17	12	13	34*	59	43	48	83*
25. Ability to understand other cultures and people (G–14)	17	22	25	30*	26	29	39	70*
26. Ability to understand and enjoy literature, art, and music (G–12)	13	10	16	20	34	36	32	61*

* Chi Square values (based on frequency) significant at .001 level.

The symbols G–1 through G–16 and S–1 through S–10 are the general and specific goals, respectively, as defined in the Presidents Commission on Higher Education and Kidd Report.

Table VIII lists the sixteen general goals (G1-G16) and twelve specialized goals (S1-S10) in decreasing order according to the percentage of alumni who felt that the goals were "Very Important." The table also lists the percentage of faculty, senior and freshman students who felt that the goals were "Very Important." The achievement data report the combined percentages for the "Much" and "Some" responses for each sample population.

The differences in the response proportion by the alumni, faculty, seniors and freshmen which resulted in chi quare values significant at the .001 level are noted with an asterisk.

Similar to the findings about the engineering education goals, there was considerable agreement on the general education goals that stressed logical thinking, oral and written communications, and an understanding about human relations. Only a small minority stressed the goals that emphasized manual skills, an understanding of other cultures, and an enjoyment of literature and music.

Some interesting differences were noted in the four groups. Engineering faculty members were less apt to stress the importance of goals which emphasized social relations and vocational orientation. The freshman students held the opposite point of view in that they stressed the importance of the social and vocational goals.

Insofar as achievement was concerned there was considerable agreement by all groups on the goals which emphasized human relations, communication skills, and vocational skills. The goals least likely to be achieved were those which emphasized the recognition of world interdependence, understanding other cultures, and the understanding of literature, art, and music.

Similar to the engineering education goals, the freshman students were the optimists and the faculty the pessimists. The faculty were more apt to feel that their students achieved the goals which emphasized health, family relations, and getting along with other people than did the alumni and senior students.

In addition to the comparisons discussed, hypotheses were tested which dealt with the relationships between the rankings of the goals by the four populations. The principal results on the tests of these hypotheses were as follows: a positive relationship existed in the ranking of goals for both achievement and importance between the four populations and within the four populations; that is, the goals that ranked high in importance for the alumni also ranked high among faculty, seniors and freshmen. Similarily, the goals that ranked high in achievement for the alumni population also ranked high in the other groups. Among the individual groups, a goal that ranked high in importance was accorded a high ranking in achievement.

Within the alumni population the educational goals and subjects were compared in four ways: degree area, year of graduation, present job functions, and scholarship ranking. For most goals and subjects significant differences were noted when analyzed by degree, year of graduation, and present job function. The alumni with degrees in chemical, metallurgical, aeronautical, and agricultural engineering usually reported the greatest deviations. The analysis by year of graduation revealed that the younger alumni usually reported a higher achievement in the specialized goals. The younger graduate also placed a greater emphasis on the importance of a technical-scientific orientation to education. In the job functions of an engineering nature the teacher reported the greatest deviations. Comparisons between the engineering and

nonengineering functions revealed that those engaged in engineering emphasized the scientific-technological goals and the nonengineers emphasized the social-humanistic goals.

In summary, it can be said that although the attitudes of alumni, faculty and students differed in many specifics, there was considerable similarity in their views regarding the importance and achievement of educational goals and the engineering curricula.

Conclusions

Some of the more important conclusions evidenced by the study data were:

1. Twenty-five per cent of the alumni with twenty-five to thirty years experience reported that they had had but one employer.

2. About 80 to 90% of the Purdue engineering graduates pursued a career in engineering throughout their active career. Over 50% of the alumni were employed in the engineering field in which they received their degree. The versatility of an engineering training was evidenced by the fact that over 20% were employed in a field of engineering other than that in which they received their degree.

3. Over 30% of the alumni were engaged in design, research and development within five years after graduation, a fact which suggests that engineers are employed in capacities consistent with their training.

4. About 35 to 40% of the alumni were in management positions twenty-five to thirty years after college graduation.

5. The average engineering graduate required approximately fifteen years to entrench himself firmly into the profession. He reached his top position in approximately twenty-five years.

6. Twenty-five years after graduation, 50% of the alumni held at least the job title of "Assistant Chief Engineer." Within thirty years after graduation, 25% held the title of "Vice-president" and 10% held the title of "President."

7. Good scholarship was invaluable in terms of salary and position. The better students were more apt to hold more responsible jobs and receive higher salaries.

8. Graduate study had remunerative value only at the doctor's degree level. A master's degree seemed to have little bearing on future income.

9. There were significant differences in the attitudes of the alumni, faculty, seniors and freshmen regarding the extent to which they felt that the various educational goals were achieved through formal study. The freshmen were the most optimistic and the faculty the most pessimistic.

10. Whereas the alumni favored more practical study in the formal engineering curricula, the faculty urged a theoretical approach.

11. Opinion was divided about the curricula which could best serve the professional requirements of engineering. Alumni favored a five-year co-operative program; the faculty and seniors favored a more scientific program; and the freshmen were about equally in favor of a four-year program similar to the present one or a five-year program similar to the present one or a five-year program with a co-operative or scientific emphasis.

12. Over 90% of the alumni favored an annual report on the changing views in engineering. This suggests that engineering graduates have a keen interest in the status and progress of the educational viewpoints of their profession.

Acknowledgments

The authors express their sincere appreciation to the alumni, faculty and

students who participated in the study. They also owe much to their many colleagues at Purdue University and the University of Illinois who provided counsel in the planning phase as well as the analyzing and synthesizing phases of the study. Individuals who deserve special mention are Dean W. L. Everitt and Professors K. B. Henderson and P. J. Runkel of the University of Illinois and Professors H. H. Remmers, L. E. Isaacson, and N. M. Downie and Miss Betty Bain of Purdue University.

SUMMER INSTITUTES FOR TECHNICAL INSTITUTE FACULTY

The National Science Foundation has awarded grants for the support of an eight-week Summer Institute at the University of Houston and a three-week Summer Conference at The Pennsylvania State University. The institute and conference are designed for faculty members in technical institutes and in technical curricula in junior colleges. The principal objective of each grant will be to improve the subject matter competence of teachers in science and closely related areas.

The Summer Institute at the University of Houston will offer a program at the graduate level and a program at the undergraduate level, in the general areas of electrical and mechanical engineering with appropriate accompanying mathematics. Participants can earn six hours of graduate or undergraduate credit. The opening date will be on or about July 1, and the closing date on or about August 27, 1959. Financial support will be available to at least 40 participants. This will consist of a stipend of up to $75 per week, dependency allowance of up to $15 per week per dependent up to four, travel allowance not to exceed four cents per mile for one round trip between home and Institute, plus exemption from tuition and fees. Further information and application blanks can be obtained from the Institute director: Dr. R. W. Bingham, College of Technology, University of Houston, Houston 4, Texas.

The Summer Conference at The Pennsylvania State University will offer a program in instrumentation and control, with endorsement by the Foundation for Instrumentation, Education and Research, Inc. Minimum academic preparation required is the Bachelor of Science degree in engineering, physical science, or mathematics. No academic credit will be given. The Conference will begin July 6 and end July 24, 1959. Support will be available to at least 25 registrants in the form of a stipend of up to $285 and a travel allowance of not more than four cents per mile for one round trip from home to the Conference, plus exemption from tuition and fees. Further information and application blanks can be obtained from: Professor B. W. Niebel, Head, Department of Industrial Engineering, The Pennsylvania State University, University Park, Pennsylvania.

WHAT THE COLLEGE SHOULD EXPECT FROM THE HIGH SCHOOL MATHEMATICS PROGRAM

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Presented at the joint meeting of the Mathematics Section of ASEE and the Northern California Section of the Mathematical Association of America, June 17, 1958, University of California, Berkeley. Recommended by ASEE's Mathematics Section.

Let me begin by saying that I intend to speak primarily of the needs of students who come to college from high school intending to study engineering or other sciences or mathematics as a field of concentration in college, or who expect to take calculus for one reason or another. My first observation is that these students should at least be ready to begin analytic geometry and calculus as their freshman course in mathematics. The college should expect the high school to have prepared them properly for such a course. I assume that these students are of normal college preparatory calibre and able to pursue with profit regular college preparatory courses in high school. I defer consideration of "gifted" students until later.

What should the college expect these "normal college preparatory courses in mathematics" to include—or, rather, what should it expect the entering freshman student of analytic geometry and calculus to possess as mathematical equipment as a result of having passed such courses with recommending grades? Let me first say what I believe constitutes an irreducible minimum—I shall later discuss a truly desirable preparation. From his algebra he must have retained the ability to factor simple expressions—such as, for example, the difference of squares, quadratic expressions, expressions that yield to "factorization by grouping of terms," and the like. He must be able to simplify fractions and expressions involving fractions, to solve quadratic equations by factoring, completing the square (an especially important method), and by formula, to solve systems of linear equations in two, three, or more, unknowns, and systems of one linear and one quadratic and of two quadratic equations in two variables (not the "tricky" cases though), and to deal intelligently with expressions involving radicals. He should have become accustomed to a reasonable notation—he should be able to solve equations in which some letter other than "x" represents the unknown. He must know the elements of operations with inequalities. He must be familiar with the laws of exponents and of logarithms. He ought to have a reasonably good *understanding* of these topics and to have an appreciation of the fact that algebra is actually a deductive mathematical system based upon some undefined terms, definitions, and axioms, although of course, it is unwise to expect too great a degree of abstraction at this point in his mathematical career. There are, certainly, many additional topics of importance in algebra that are desirable preparation; but I am speaking now of a *minimum* preparation.

In geometry the notions of congruence, similarity, perpendicularity, par-

allelism, etc. are indispensable. The Pythagorean Theorem is basic to any future work in mathematics. Geometry plays a valuable role as an illustration of a deductive system of reasoning, and this aspect must not, of course, be underemphasized. It is pertinent, however, to point out that it is unfortunate that the high school student too often has received the impression that geometry is the *only* such illustration; hence my reference to putting some emphasis upon this aspect of algebra. Not only must the student know something of plane geometry, but he must have some knowledge of the geometry of three dimensions. I am willing to grant that, for a minimum preparation, formal work in "solid geometry" can be left out, and the student left to improvise as best he can in this subject. But some development of "space perception" and visualization of three-dimensional figures is absolutely essential to the student of mathematics, to say nothing of the student of engineering and other pure and applied sciences.

In trigonometry, a minimum preparation requires the general definition of the usual six trigonometric functions and how to find the other five when one is given together with some restriction as to quadrant, a familiarity with the values of the trigonometric functions of certain angles—such as 0°, 30°, 45°, and so on, the use of radian measure, and most particularly familiarity with the relations among the various functions—usually developed by proving identities. The student should know how to use the laws of sines and cosines in the solution of triangles, be able to recall and use formulas for sine, cosine, and tangent of sums and differences of angles, etc. He should have studied the graphs of the trigonometric functions, solutions of trigonometric equations, and know the periodic character of these functions. Some experience with computation with logarithms is valuable. Although the "analytic trigonometry" of which I am speaking is the most important part of the trigonometry course, I should like to say a word in defense of a reasonable amount of triangle-solving simply because of its value as an exercise in accuracy of computation, neatness of work, and organization of material. Some experience in using vectors is valuable.

In all of the work mentioned, plentiful experience in the solving of problems is indispensable. In making such lists of topics that must be included as minimum preparation for freshman college mathematics, one can add this topic, or leave that one out, and the end result is about the same. But if the student cannot translate simple English statements of problems into mathematical terms and discover the solutions of the problems, all of his and his teachers' efforts will have been wasted. A very good case can be made for the proposition that the major goal of high school mathematics should be to develop the students' ability to solve sensible and significant problems. Engineers in particular are vitally concerned with this aspect of mathematics instruction, and so are mathematicians, statisticians, scientists of all descriptions. While exercises in pure logic are intellectually stimulating, interesting, and profitable, there must be plenty of emphasis upon the problem-solving features of mathematics. All of us, high school and other teachers in particular, are well aware of this fact; but it is well to keep it in the forefront of discussion. The understanding of the logical structure of algebra and of other parts of mathematics is of great importance, and it is equally important to note that such understanding is increased by problem solving, and that the two go hand in hand.

Minimum Preparation

As far as minimum preparation is concerned, I think it fair to summarize by saying that a good working knowledge of algebra is the most important item. More students have trouble with calculus because of weakness in algebra than for any other reason. Such remarkable operations as the following occur occasionally—incredible as it may seem:

$$\frac{1}{a+b} = \frac{1}{a} + \frac{1}{b}; \quad \sqrt{a^2+b^2} = a+b;$$

$$\tan (A+B) = \tan A + \tan B$$

These are examples of what has been characterized by one of my friends in the Department of Mathematics at the University of California as the "Law of Universal Linearity." But it is not my purpose to pick out horrible—though fortunately isolated—examples.

I may say in general that the majority of students who present themselves at Stanford for analytic geometry and calculus are reasonably well prepared. Some are exceptionally well prepared, some superlatively so. Most of these well prepared students have considerably more than the minimum preparation already listed. This brings me to a second phase of this paper, namely, what is the *best* (not the minimum) kind of preparation in mathematics for the college-bound high school student of normal ability? Again I note that I shall speak of the "gifted" student later. I shall recommend the preparation that I am going to describe for all prospective engineers, scientists, mathematicians, social scientists, and even for students who are undecided about their future careers or who are unaware of future interests or needs. Who knows what interests may develop? In these days of exponentially increasing need for and use of mathematics, it is wise to be prepared for any reasonably likely contingency.

Best Preparation

Our traditional high school college preparatory mathematics has for many generations of students consisted of two years of algebra, one year of plane geometry, a semester of solid geometry, and a semester of trigonometry in one order or another. This curriculum in the hands of imaginative and well trained teachers has produced large numbers of college students who have made fine records in college mathematics. If my freshman students of calculus are masters of this material, I am well content. But we cannot ignore the fact that mathematics has changed greatly in both its emphasis and its point of view in recent years. Although research in such subjects as classical analysis continues with unabated vigor, there has been a most significant development in such subjects as abstract algebra, topology, mathematical logic, probability as used in statistical inference, etc. The mathematics needed for the operation and efficient use of modern computing machines is a development of the very recent past. Just to illustrate the impact that such a new field as theory of computing machines may have upon the mathematical needs of present-day students, I repeat some statistics cited by the Commission on Mathematics of the College Entrance Examination Board as follows: there are now on order approximately 2,200 large electronic computing machines each of which requires, on the average, ten mathematically trained men and women for its operation. There are thus created 22,000 jobs for mathematically trained personnel. It is interesting to observe that, as a contrast, the total membership at the present time of the "learned" societies for mathematicians in this country is somewhere around 10,000. The demand for mathematics has been increasing, and it will increase rapidly

in coming years. Much of the mathematics needed by graduates of our schools and colleges today will be of the so-called "modern" type.

At the same time, a great deal of the "modern" mathematics is not particularly different from the "traditional" mathematics in so far as the subject matter to be studied is concerned. In "modern algebra" one still wants to solve linear and quadratic equations, simplify fractions, etc. But the point of view from which one attacks these questions is perhaps the characteristic feature of what is called "modern" algebra. Perhaps I might attempt to characterize the nature of "modern" mathematics somewhat as follows. Modern mathematics is placing a renewed and conscious emphasis upon the notion that mathematics is primarily concerned with abstract patterns of thought, and only secondarily with manipulative skill or particular content. Modern mathematics has made a tremendous development quantitatively; there has been an introduction of new material and a revision or transformation of older subject matter. At the same time, it must not be forgotten that mathematics, unlike many sciences, has the happy property that once conclusions (for example, theorems in Euclidean geometry) have been validly drawn from properly stated premises, they remain valid regardless of new discoveries. All the good mathematics we have ever learned and enjoyed remains still good mathematics. Nevertheless, this does not mean that changing points of view, new emphases, new discoveries should not be brought to bear upon the problem of illuminating past knowledge and of formulating new.

What should be done, if anything, to improve our curricula in high school and, for that matter, college mathematics? We are at present confronted with a deluge of proposals, many with merit, many ill-considered and untried. In trying to answer the question, "What ought the college to expect from the high school mathematics program?", I think it appropriate to consider how, if at all, we might revise traditional high school and college programs to capitalize upon many of the ideas and the point of view of "modern mathematics." Furthermore, I am personally of the opinion that in many cases we should ask *more* of students than we do; many of them are not extending themselves nearly to their intellectual capacity. I am well aware of the practical difficulties involved in doing this with large classes of students with widely varying interests and ability, but it is worth recognizing in any event.

Of the various proposals I have investigated, I am most favorably impressed by those of the Commission on Mathematics of the College Entrance Examination Board. This Commission makes no revolutionary proposals for overturning the high school mathematics curriculum. It is concerned with the material to be included in the achievement tests in mathematics which may ultimately be revised in line with the proposals of the Commission. It does not pretend to say that the curriculum implied by its proposals is the best possible curriculum for all students in all high schools in the United States. In essence it can only say that here is a curriculum that will prepare the student to take the College Board tests in mathematics and to continue with mathematics in those colleges that expect their entering freshmen to meet requirements in mathematics similar to those established by these tests. This means, therefore, that we are talking about normal college preparatory students. We are not talking about the top two or three per cent of students that may be termed "gifted" and who might well be considered for

college equivalent courses in high school and for advanced placement in college.

Let me summarize briefly these proposals in so far as I am informed about them. I would say that if a student entering college with the idea of concentrating in mathematics, science, engineering,—even the "general" student—and so of starting his college mathematics with analytic geometry and calculus could have the preparation here indicated, that his high school would have fulfilled its obligation to him in a most satisfactory manner. It is proposed that the first three years of high school mathematics—that is, ninth, tenth, and eleventh grades—divide the instruction in roughly the following proportions: algebra 50 per cent, geometry 35 per cent, trigonometry 15 per cent. I shall discuss this in some detail before taking up the matter of the twelfth grade. I shall try to indicate what material is proposed for inclusion without any attempt to suggest the exact sequence or organization—this is really a matter for local determination.

I think it is fair to say that together with such material already cited as part of the minimum content, the usual topics of three semesters of algebra are to be included. Perhaps more stress than is now common might be put upon inequalities—in passing let me say that a case could be made for the proposition that inequalities are actually more important than equations. A serious attempt should be made to illuminate the structure of algebra and to avoid any implication that the subject consists of just a bag of tricks. That is to say, for example, the commutative and associative laws of addition and multiplication and the distributive law of multiplication with respect to addition can certainly be mentioned by name and properly explained. The importance of such laws and their basic role in algebra must be made clear if the student is to have a real understanding of the subject. For example, there is an enormous amount of mystery about the rule that, if a and b are positive numbers, then we define $(-a)(-b) = ab$. Algebra books, it seems to me, too often make a very labored justification of this by attempting to find physical or other examples to motivate it. Actually this definition is made so that the distributive law will hold for operations with negative numbers. I see no reason why an intelligent high school student should be shielded from knowledge of this fact.

Some discussion of such matters should be included. Good teachers have always done something of the kind. But we must somehow include suggestions like this in course outlines or textbooks, or not all teachers will be aware of their importance. I am astonished in picking up an algebra book by well-known authors copyrighted in 1956 and finding the "commutative law of addition" mentioned in the index, but no reference to associative or distributive laws. I hardly think this is too great a concession to modernity to expect.

In this same textbook directions for dividing one fraction by another are given as follows: "Fractions in algebra may be divided by the methods used in arithmetic. *First method:* In this method we shall invert the fraction by which we are dividing and multiply." And so on. This is the only reference to division of fractions to be found in the index. I am willing to wager that many students of algebra do not really know any reason for performing the arithmetical stunt to which this text refers. Why not take a little time and explain? Some attempt to clarify concepts and rules seems called for if this text is typical (and I have reason to believe it is). The full paraphernalia of abstract algebra need not be intro-

duced at this point, but certainly some serious attempt ought to be made to present algebra as a deductive system.

There are, it seems to me, some topics traditionally included in the algebra courses that need more emphasis than they receive. I, for one, expect my freshman students to know what a determinant is and how to find the value of one. I am constantly distressed by the fact that so many students seem to be strangers to mathematical induction and even to the binomial theorem. Proposals for revisions of curricula should, in my opinion, take account of this.

There is some disposition on the part of the Commission to ask that some of the basic notions of set theory be introduced early in the work in algebra. I think this could well be helpful to the college preparatory student. Actually much of this work involves chiefly new names for things already familiar. But the ideas of a set, a subset, intersection of sets, union of sets, etc. are of great generality and can serve as unifying concepts for many parts of mathematics. Why not use the word "set" wherever it is applicable—for instance, a *locus* is a *set* of points satisfying some specified condition.

Geometry has traditionally been the course in which deductive reasoning has been stressed. This is all to the good; let us continue this stress, but not confine it to geometry! It is clear, however, that it is quite impossible at this point in the student's career to try for a completely rigorous development based upon the smallest possible number of axioms. Rather than become involved in vague references to superposition, it is probably best to assume as axioms some of the congruence properties of triangles—at least congruence of two triangles having two sides and the included angle correspondingly equal. The college teacher does not have to draw much upon his students' recollection of formal proofs, although such proofs are important for other reasons. The Commission on Mathematics will probably recommend that some dozen basic theorems be carefully proved and the students held for the proofs. These will culminate in the Pythagorean Theorem. At this point, coordinate geometry can be successfully introduced with formulas developed for mid-point of a line segment, slope of a line, distance between two points. The methods of analytic geometry can then be exploited, together with those of the familiar synthetic geometry, in the proofs of numerous theorems. There is great opportunity for original and creative thinking in the study of geometry, and a large part of the course should be devoted to original exercises involving both the discovery of relationships and their proofs. Further, there seems to be no reason why the geometry course should be sharply divided into parts on the basis of dimensionality—for example, one-dimensional and two-dimensional geometry are inextricably interwoven. I should say, in harmony with recommendations of the Commission, that it is both possible and desirable to teach certain material of three dimensional geometry along with analogous content of plane geometry.

In regard to solid geometry, let me say that I am aware of a number of statements that recommend its being dropped from the high school curriculum. Such an action can be justified or condemned depending upon the interpretation given to it. In my opinion, the traditional content of a solid geometry course probably does not warrant devoting a full semester to it —there are other topics of importance that are thus crowded out of the curriculum. At the same time, the student of freshman and sophomore college mathematics—to say nothing of

other more advanced mathematics or engineering subjects—is greatly handicapped if he does not have some "space perception," some ability to visualize objects in three dimensional space. He needs to know about parallel and perpendicular planes, lines, etc., something about spheres and other solids. Nothing is more annoying than to find that college students don't know formulas for volumes of spheres, cones, cylinders, not to mention common formulas connected with measurement of plane figures. Perhaps a good solution of the problem of what to do about solid geometry is to suggest putting the really important parts of it into the course in which plane geometry occurs.

The introduction of elementary analytic geometry early in the geometry course has many advantages. Here is a natural device for maintaining skill in algebra as well as a means of throwing considerable light upon algebraic relationships. It becomes a unifying principle—one more means by which we can show that mathematics is not a collection of isolated subjects, but one unified discipline.

Trigonometry may well be introduced at various places in the work of the first three years of high school mathematics, but some concentrated study is needed, perhaps in the third year. Too often we have found our college freshmen thoroughly drilled in the solution of triangles, but quite unfamiliar with the important elementary properties of the trigonometric, that is, the circular functions. Although I have already indicated that I think some experience in accurate computation and in dealing with significant figures is important, and that computational trigonometry furnishes a good subject for practice, still several weeks spent in solving problems consisting mainly of finding the sides of triangles to five significant figures and angles to the nearest second, with all the ramifications of the ambiguous case, is to a large extent time wasted in the light of present-day needs. The major effort should be on what might be called "analytic trigonometry"—a thorough study of the trigonometric functions and relations among them; their periodicity; their graphs and variation; the inverse trigonometric functions.

So much for what we ought to get into the first three years of high school for this college preparatory group. What about the fourth year—the twelfth grade—for these students? The Commission on Mathematics of the College Entrance Examination Board has spent a very considerable amount of time and effort on this question. I may report to you one negative result, a conclusion with which I agree. It is pretty clearly the opinion of the Commission that, for the group of normal college preparatory students, it is not desirable to attempt a course in calculus as the work for the senior year. It would appear that the Commission will probably recommend a semester to be devoted to what might be termed "mathematical analysis," and a semester to probability and statistical inference. It is assumed that some acquaintance with simple descriptive statistics has been made earlier in the student's career in mathematics. The Commission has recently published an experimental text called *Introductory Probability and Statistical Inference for Secondary Schools* that might be used in the one semester course just mentioned. The college student would find the knowledge obtained in such a course of great value to him whether he follows a college course in mathematics, engineering, physics, chemistry, social science, and so on. I would hope that the work in mathematical analysis in the other one semester senior course would include such topics as review and further careful considera-

tion of the meaning of "function," additional work with progressions, introductory work in series, complex numbers, DeMoivre's Theorem, roots of unity, some topics from the theory of numbers, some elementary theory of equations not already covered, introduction of the postulates for a field, some elementary notions about matrix theory, perhaps an introduction to limits and the derivative of polynomial functions—largely for the purpose of applications to curve tracing. Additional work with inequalities should be included, and particular attention paid to approximations and limits of error in computations. In general, I might say that many of us in the colleges would prefer that the student get a broader, and also deeper, training in algebra and allied subjects than to get a necessarily sketchy introduction to calculus.

Gifted Students

I have left until the last any remarks about the "gifted" students in high school mathematics programs. During the present days a good deal has been said about the plight of these young people. I am afraid that, in some cases at least, we are tending to see too many supposedly "gifted" students. Programs for them are popular at the moment, and it is a great temptation to want to set up a mathematics course for such students when, in reality, there may be none—or at most one or two—in the whole school, and no teacher really in a position to give the kind of work appropriate. We should be cautious, and extend the privilege of special work for gifted students only to students who really are gifted. One hears occasionally of a school of two or three hundred students in which it is proposed to give a college equivalent course in calculus to a class of a dozen or twenty students. I admit that this is a rare case, but it serves to make the point. Nevertheless, there may well be a few students who have unusual mathematical ability. They should be identified as early as possible. It is quite likely that such students could start the usual ninth grade college preparatory mathematics in the eighth grade (or even earlier!). This is being done in some school systems at present—it is especially appropriate where the system is organized on the junior high school-senior high school basis. Such students would normally complete the usual four-year college preparatory mathematics course at the end of the eleventh grade. What is to be done in the senior year? Of course, one thing to do would be to graduate them earlier and let them go on to college! If the school has on its staff a teacher who is willing and able to do it, the student might be given a college equivalent course in analytic geometry and calculus—one that would qualify him for advanced placement and/or credit in college. If this is not feasible, he might be allowed to attend a local junior college or college if one is available where he could pursue the regular freshman course in calculus. If he is isolated in a place where none of this is possible, he might be encouraged to enroll in a university extension course in calculus. He might be given special reading in mathematics other than calculus if his teacher believes himself better able to guide such a program than to teach a college equivalent course in calculus. There are many possibilities.*

* It might be appropriate to mention very briefly a few sources of excellent material beneficial both for the teacher and the gifted student. I name only four items by way of illustration—there are many others. These are:

Polya: *Mathematics and Plausible Reasoning*

Courant and Robbins: *What is Mathematics*

Newman (editor): *The World of Mathematics* (4 vols.)

Insights into Modern Mathematics, the 23rd Yearbook of the National Council of Teachers of Mathematics.

While it is not possible in a short time to detail in full what I think the college should expect from the high school mathematics program, perhaps these remarks may suggest the general nature of what might be expected from students who reach different terminal points in their high school mathematics. I hope, particularly, that some suggestion as to the quality of the work has been made clear—let us teach for understanding as well as for skill; let us introduce what is relevant and appropriate in so-called "modern" mathematics, particularly its point of view; let us be sure that students gain power in problem solving; and let us be sure that what we do contributes to the student's power to deal with unfamiliar intellectual problems.

FOUNDATION INVITES PROPOSALS FOR CONSTRUCTION OF BETTER LABORATORY EQUIPMENT IN U. S. SCHOOLS

Scientists and science teachers in colleges, universities, and nonprofit organizations have been invited by the National Science Foundation to submit proposals for the construction of better laboratory equipment for use in the Nation's schools. Proposals judged meritorious will be supported by the Foundation under a program designed to encourage the development of inexpensive and practical tools for use in the laboratory phases of science instruction.

Under the terms of this new, experimental program, the Foundation will consider proposals for the design and construction of improved laboratory equipment and for the development of new instructional materials for lecture demonstrations, laboratory and field work for courses at elementary, secondary, and undergraduate college levels in mathematics, astronomy, earth sciences, physical and biological sciences, and engineering.

Proposals, signed by the project director and a responsible officer of the sponsoring college, university, or scientific organization, should clearly describe the work to be done, give the qualifications of the personnel involved, show how the proposed material will be evaluated and eventually made generally available, and present a detailed budget. Support under this program will *NOT* be provided for the purchase of equipment for refurbishing school and college laboratories, or for commercial production of equipment or materials.

Proposals should be sent to the Course Content Improvement Section, National Science Foundation, Washington 25, D. C.

REFLECTIONS ON TEACHING I HAVE SEEN

RICHARD M. SUTTON

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After more than thirty-five years of conducting classes, I was asked by Dean Karl B. McEachron of Case Institute to turn my attention to ways of improving the classroom instruction of engineering students. This is a report on some of my findings to date. It is necessarily incomplete and admittedly open to extension in numerous directions.

The Method

During the Spring of 1958, I attended nearly two dozen classes taught by as many instructors, mostly younger men but not exclusively so. In advance of my visit, I would explain my purpose to the instructor, asking if I might come as "a sympathetic and objective observer, as much interested in what the students are doing as in what the instructor is doing." In setting up the program, I had specifically pointed out that I had no desire to serve as a stooge for the administration, that my findings should be made known to the men whose classes I visited, and only in general terms to the administration. Either at the conclusion of a class, or soon thereafter, I would find opportunity to discuss the whole procedure with the individual instructor in person, giving him as helpful and constructive a summary as I could.

Now, as a physicist, I was fully aware of the Uncertainty Principle, which starts from the premise that the manner of observing any phenomenon affects the phenomenon observed. The physical presence of a stranger in a class cannot help but modify the behavior of all others present to a greater or less degree, despite his silent and unobtrusive shrinking into the background at the rear of the classroom. Least of all can the instructor forget his presence. Furthermore, the observer is likely to view proceedings through the highly astigmatic glasses of his own teaching experience. Whatever teaching faults he observed could be matched in his own past practices, and he doubtless could offer an impressive supplementary array all his own. Allowing fully for these disadvantages, there is still a residuum of possible values to be gained from such observation.

In a number of cases, the observer found it hard to imagine how the classroom operation could have been rendered more effective. In others there was evident room for improvement on the part of the instructor, and in many there was great room for improvement on the part of the students. It is with this aspect of the classroom situation that I am deeply concerned, for I believe it poses the greatest need of all. Not all poor classroom situations are demonstrably the fault of the instructor: the students also have a responsibility for their own progress that is often poorly discharged. I observed far too much passivity, sluggishness, and lack of an active and aggressive approach to the learning process on the part of large sections of many classes. It was as if the instructor were struggling to set an inert mass into motion. However, I cannot completely exonerate instructors who are faced with the problem. They or

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their predecessors may have been responsible through the years for the build-up of undesirable attitudes. The alert instructor meets this as a challenge and works to overcome the handicap of bad habits and attitudes which he may have inherited in the human material he is about to mold.

Some Things to Cultivate— Some Things to Avoid

Opposite to every positive aim in the conduct of a class, one may readily place its negative. First, let me describe an imaginary class at its best, and then a class at its worst.

In the ideal class, the aim of the instructor is to engage everyone in an active learning process where each person advances at a rate worthy of his own ability and potential. To accomplish this, the instructor is aware of his students *as individuals*. He sets a challenging intellectual pace that engages their interest. Good humor and *esprit de corps* help to keep the class awake and enthusiastic in its wrestling match with new ideas. A friendly rapport exists between the instructor and his students because they have confidence in his good will, knowledge and ability, and he has confidence in their willingness and ability to learn. He also has confidenc in himself but is not complacent in his own ability. Both the instructor and his students are in the process together, both are learning continually, albeit at different levels. There is a spirit of give-and-take that keeps all relationships alive, while still under the unasserted control of an overall discipline of mutual respect for persons and for learning. By his alertness, voice and manner, the instructor keeps each member of the class involved. There is an active two-way flow of questions. The class has an atmosphere of life and vitality that is interesting to watch. The end of the hour finds the class faced with unsolved questions and new challenges.

A composite of all the worst aspects would look something like the following picture which, fortunately, was not encountered in any one class. The students sat or slouched anywhere they liked, mostly near the back of the room; they seemed ill-prepared and disinterested in the subject being taught. Some dozed. A low purposeless bustle of confusion existed—a random Brownian movement of papers, books and men. The instructor droned along in a flat voice almost devoid of inflection, drooling commonplaces on academic matters having no apparent connection with real life or the interests of his students. He was more interested in what he was writing (often illegibly) on the blackboard than in his class, and seldom gave evidence that he was aware of a class composed of individual persons. He asked all the questions, mostly rhetorical ones, then proceeded to answer them himself, seldom having the courage to probe deep enough to find whether the question had reached any listener, let alone whether the listener had any interest in either the question or its answer. The general passivity of 80% of the class was marked: they doubtless looked upon the active 20% either as "apple polishers" or with a kind of thankfulness that these alert ones were keeping the instructor sufficiently involved so that the hazard of *their* ever being disturbed was reduced. The thing that seemed to matter most was whether they could pile up enough useful ideas for the next exam. The class hour under such circumstances would turn principally into a recitation on the day's subject by the instructor, far too much a one-man show in which others present were scarcely involved. A minute or two before the bell rang, there was a general shuffling of preparation to move on to another hour of the same kind.

A K-Ration of Advices

In offering the following "Advices" compiled from my observations and reflections thereon, I have tried to touch on some of the things a teacher must heed. Any similarity to like suggestions published in the past is entirely coincidental.

1. Know your subject thoroughly. Take plenty of time to prepare, no matter how often you have covered the subject before. Be thoroughly acquainted with derivations. Think about your subject creatively so that you have looked at it from many angles and have asked yourself many of the questions likely to be asked by your students. Create problems: half the fun in teaching comes from asking yourself questions you can't answer, then searching for answers! Keep imagining ways to relate your subject to the interests (and future needs) of your students.

2. Be ready to say "I don't know" to a student's question—but then do not rest content until you *do* know. Come back to the next class with an answer that shows you respected his question, you have thought about it, have followed it further and have benefited by removing some of your own ponderous load of ignorance. Questions applying to later aspects of the subject can be safely postponed by partial answers and a promise of fuller treatment. *Keep your promises!*

3. Present your subject with enthusiasm, variety, and all the skill you can muster. Don't miss the drama and life in situations. There is no excuse for dullness on the part of the teacher: make your topic vivid, as if it were, for the moment, the most important idea in the world. If you are not personally interested in the subject, don't expect your students to be.

4. Keep a free two-way flow of questions. Sarcasm or a response that attacks the questioner will squelch student questions quicker than anything else. It takes a hardy student to stand up under public rebuff and come back for more. Even the threat of rebuff will keep most students silent. Don't answer all your own questions until you have explored the class for their ideas. Don't do all of the "reciting" yourself. In small classes, I have a distrust for too much "lecturing" by the instructor. This does not mean that he does not have a primary responsibility for clear exposition, but this should be kept fully ventilated with frequent "feed back" from the class to assure the safe arrival of ideas.

5. Be clear in speech:—give your voice a ring and some adequate range of inflection. Mumbling or a flat and uninteresting voice can kill student interest, no matter how clear your ideas may be.

6. Know your students by name, and *use* their names. All too seldom did I hear a student spoken to by name. There is probaly no more certain way to secure active interest than to pose a question to an individual when the rest of the class knows that you will pepper several other individuals in rapid succession with extensions of the same question. When a student indicates his desire to ask a question, respond to him by name. Cultivate the person-to-person aspect of developing ideas in class, but be sure that you don't let one student usurp your attention to the point of losing the rest of the class. Every class does not have to be a pepper pot of questions; but some questioning is useful, even in the midst of "lecturing."

7. Be unhurried and definite in making advance assignments, writing them and speaking them so as to appeal to eye and ear. Take some time to engage student interest and understanding in what lies ahead. Present it as the next challenge worth meeting.

8. Take time to go over past exams

soon after they are taken, using them as an instructional tool, not just as a grading device. Your demonstrated interest in the accomplishments of your students will do much to make them seek a thorough understanding of the subject rather than just to gather grades.

9. Work for a cordial relationship with individual students and with the class as a whole, based upon mutual respect and a spirit of cooperative enterprise. Your interest must be genuine: if you begrudge the time devoted to preparing for class and teaching, your students will detect it.

10. If necessary, restrain meaningless noise or disturbance, but try to make such direct restraint unnecessary by the kind of purposeful activity you promote. Cooperative self-discipline is to be sought,—not an imposed discipline. Be not unaware of the physical conditions of the classroom: i.e., do not be so completely absorbed in your own ideas as to be unmindful of distractions and disturbances. If these are external and beyond your control, indicate your awareness of them by some good-humored remark, but then show your intention to rise above them and to have your class do likewise.

Finally, do you consider your teaching an important responsibility or just a means to some unrelated personal end? If the latter, it may be better for you to step down and let someone who *wants* to teach do the job. But don't give up until you have given this rewarding and challenging occupation your best effort. Building people into the engineers of the future may be fully as important as building dams, generators, skyscrapers, jet planes or Moon-girdling rockets.

TOWN NAMED ENGINEERING DEAN AT IOWA STATE

Dr. George Town has been named Dean of the Division of Engineering at Iowa State College. His appointment was announced by President James H. Hilton. At the same time, President Hilton announced two other administrative appointments in the Division of Engineering: Dr. David R. Boylan, Jr., was named associate director of the Iowa Engineering Experiment Station, and Dr. John E. Lagerstrom will become assistant dean of engineering for academic teaching. All three appointments became effective March 1, 1959.

Town succeeds J. F. Downie Smith, who resigned December 31, 1957, to accept a research position in industry. During the interim period, the division has been under the leadership of M. S. Coover, former head of the department of electrical engineering. Coover will become dean emeritus of the Division for Engineering. For the present he will serve as acting head of the department of civil engineering.

CO-OPERATIVE EDUCATION IN CANADA

IRA G. NEEDLES

Chairman of the Board, B. F. Goodrich Canada Ltd., Chairman of the Board of Governors, The University of Waterloo Associate Faculties

Presented at the Mid-Winter Meeting, Co-op Division of ASEE, Chicago, Illinois, January 7–9, 1959.

In Canada we have our provincially operated universities, such as The University of Toronto, that correspond to your state universities. We also have independent universities which, provided they are not sponsored by a church, receive large annual capital and operating grants from the province. In Ontario, the provincial government does not financially support the church-related colleges. This has resulted in two things: (1) several of the universities that were originally church-related colleges dropping their church relationship in order to procure provincial financial support; (2) a system of affiliated colleges has been established. Through this plan, the church-related colleges become affiliated with a university receiving provincial financial support. Provided the affiliated college is located near the provincially supported university, it may operate at a lower cost through having available to its students some of the facilities provided by the government supported university.

Another part of the university program in Canada which is different from the United States is that the universities receive their right to grant degrees through an Act of the Provincial Parliament and there are no provincial or state accrediting associations.

A knowledge of these differences between the systems of higher education in the United States and Canada will enable you to more easily understand the development at Waterloo which I will describe to you.

We are in the stage of giving birth to Canada's newest university, which will be known as The University of Waterloo. Waterloo College has been operated as a Lutheran church-related liberal arts college since 1914. About three years ago I was asked by its president to meet with him and a few other business people in Waterloo and Kitchener to discuss the formation of a non-denominational college. The non-denominational college, being eligible for provincial grants, makes possible the continuing expansion of higher education in the community. The non-denominational college was incorporated under Letters Patent without the right to grant degrees. Both it and the church-related college are now affiliated with the University of Western Ontario, from which our graduates receive their degrees. As The University of Western Ontario is located in London, Ontario, 70 miles from Waterloo, its facilities are not available to our students.

It is anticipated that The University of Waterloo will receive its charter in the Spring of 1959. Following that, the church-related college plans to sever its relation with The University of Western Ontario and become a federated college with The University of Waterloo. At the present time, the instructors for the Humanities and Social Sciences are provided by the church-related college, while the Sci-

ence and Engineering Faculties are provided by the non-denominational college. When The University of Waterloo is established, all faculties will academically be under the control of the University Senate regardless of whether they are employed by the University Board of Governors or by the church-related college Board.

Until 1957 we were offering only the science electives for the first year of the liberal arts curriculum. We had only two science instructors, plus two chemistry and one biology laboratories.

When it was established that provincial funds would be available for the expansion of our science departments, we began to explore the existing needs in the fields in which we might expand. In doing this, it was natural that our attention should be focused on the much-publicized future shortage of graduate engineers.

The enrollment of engineering students was taxing the capacity of our Canadian universities to the extent that most universities were materially raising their admission standards. In spite of this, our universities were experiencing up to 40% failure rate in the first two years of the engineering courses. This high failure rate led us to start asking questions of both undergraduate and graduate engineers. The answers to our questions convinced us that many students selected engineering courses because of a desire to do technical work. For example, parents would say that ever since Johnny had been in public school he has been building radio and television sets in the basement and that he wants to be an electrical engineer. The truth of the matter was that Johnny visualized himself as a technician rather than an engineer. When he entered college he was frustrated by the heavy curriculum loads of math and science. He failed to realize the importance of these subjects to the work that he wanted to do.

It was during the time that we were attempting to find the reasons for the high attrition of engineering students that our attention was drawn to the co-operative courses being offered in the United States.

A few graduate engineers and top executives of leading Canadian companies convinced us that co-operative engineering education merited a thorough study. This required staff and money. Fortunately, we were able to persuade the Ontario Provincial Minister of Education of the value of such a study and to procure from the Province a grant of $25,000 for that purpose.

Before the study was completed and the final report prepared, more than $40,000 was expended. Representatives from our college visited nine of the United States universities offering co-operative education. We certainly appreciate the information that was provided to us by these universities. In the United States, co-operative education has undergone many changes since it was first established in 1904. We feel that we are fortunate in having available to us some of the lessons which you have been obliged to learn through the hard school of experience.

What we are doing is without precedent in Canada, and probably without precedent in the United States. Some of the unusual aspects of our development are: (1) Since July of 1957 our science and engineering faculty has grown from 2 to 36. (2) Since that same date we have enrolled 458 students, more than half the number of new students registering in the engineering department of Toronto University, our largest provincial university. (3) In a period of only one year, more than 140 Canadian companies have committed themselves to co-op-ate with the college and accept stu-

dents for their work assignments. (4) All of this has happened previous to our procuring a charter authorizing us to grant degrees. (5) The non-denominational college sponsored the development of the co-operative engineering course when the only property it owned was a football stadium and a gymnasium. This unusual circumstance was also the result of a co-operative effort. (6) Within less than 12 months we acquired 200 acres of land for a new campus site, constructed and occupied our first science teaching building, the Chemistry and Chemical Engineering Building with 54,000 sq. ft. of floor space. (7) Our Physics and Mathematics Building, which is more than twice the size of the Chemistry Building, is now under construction and will be ready for occupancy October 1959.

Certainly this rapid and unusual expansion is the result of our having made available the first co-operative engineering course in Canada. We have been exceptionally fortunate in the timing of its introduction. The result is that both our college and the course itself have received widespread publicity throughout Canada. This has done much to attract students, as well as to help us procure co-operating companies. We have also been very fortunate in other ways. For example, having a brand new campus permits us architectural freedom in planning our building. We are able to take advantage of new low-cost materials and methods of construction.

We also believe that it has actually been an advantage to us in having to procure an entirely new engineering faculty. We have been able to attract well-qualified instructors. As all of them are taking part in the development of the program, there is an unusual enthusiasm for it throughout the whole faculty.

Our engineering curriculum offers electives in 5 fields—chemical, electrical, mechanical, civil and engineering physics.

The School Calendar

We are registering new students only twice a year—at the end of September and at the beginning of January, although the students are co-oping on a quarterly basis. They spend eleven weeks on campus, alternating with twelve weeks in industry. This gives them two weeks holidays each year—one in the summer and one between Christmas and New Years. All of our faculty members for the co-operative course are employed on a basis of having a nine-month teaching responsibility. This works out to a teaching responsibility of 33 weeks for the co-operative course as against approximately 27 weeks in Canada for the conventional courses. We have, therefore, adjusted our conventional salary scales upward by about 20% for those who are teaching in the co-operative course. We do not encourage our instructors to teach the four quarters each year, although we do give permission occasionally for them to do so under certain circumstances. Those who teach the fourth quarter are employed for that period on a sessional basis. This method of employment has proved quite satisfactory and makes our salary scales for the co-operative course attractive in relationship to the salaries being paid for the conventional course of other larger universities.

In our Co-ordination Department, we have employed only professional engineers or science graduates. We now have 5 men in this department, or one man for approximately each 100 students.

We are very proud of the job that this department has done. Placing over 450 students in such a relatively short time is no mean achievement—especially when one realizes that they were starting from scratch. I under-

stand that the ratio of students per co-ordinator at Waterloo is low as related to some of the United States colleges. It must, however, be remembered that our men are carrying an exceptionally heavy load at this stage in our development. In addition to the regular work of placing and counselling students, they have also had to develop their record system.

We are convinced that it is through the Co-ordination Department that the co-operative program provides its major "plus" for an engineering education. Those of you who are familiar with the work of the Co-ordination Departments know that the Co-ordinators must get to know the students as individuals if they are to do their jobs properly.

A very large percentage of our co-operating companies send their representatives to our campus to select students they employ. This we believe to be highly desirable as it helps to make the employers recognize that they are the major partner in training and educating the engineering students.

In Canada, the conventional engineering courses are four years beyond secondary school Grade XIII. As our students are on campus only 22 weeks in each calendar year as against 27 weeks in the conventional courses, we have extended the total time of our course to 5, in place of 4, calendar years. In the 5 years of our course, the students have approximately 10% more time on campus than those taking the 4-year conventional courses. Our faculty is endeavoring to make good use of this additional time in strengthening our curriculum in mathematics, science and the humanities.

We have now formed an Industrial Advisory Council made up of representatives from leading Canadian companies that are interested in the engineering field. This Council is now getting organized and we are enthusiastic about the help we expect to receive from it.

Industrial Education Conference

Last May we had an Industry Education Conference on the campus. About 200 representatives from Canadian companies attended. During the day we explained our program to them in detail, and provided ample time for questions, which were freely asked. We believe that this conference served a worthy purpose and will bear repeating annually.

We realize that many of the colleges in the United States prefer to co-op their students only during the last two years of their course. We also realize that there are good reasons for doing so. In spite of this, we decided in favour of co-oping our students immediately after their first quarter on the campus. Actually, it was almost essential for us to do so.

Our preliminary survey work convinced us that co-operative education appealed to a large number of well-qualified students who would otherwise not continue their formal education beyond high school. Whether we like it or not, it is a fact that a large number of these students are attracted to this course because of the financial security it offers. Lacking this security in the early years of the course, these students would just not be interested. We needed these students because we need an annual enrolment growth of from three to four hundred students in order to justify the high cost of establishing an engineering science department.

In other Canadian universities where engineering courses have recently been established, there were previously well-established science faculties. At Waterloo, only the first year of honors science had previously been offered and, consequently, we face a very high

equipment cost, as well as a high faculty cost, because we have been obliged to develop both the engineering and science faculties.

In spite of some of the difficulties involved in co-oping students during their first year at college, we believe that there are many advantages. For the average student the first year at college is difficult. Many students fail through lack of application, rather than lack of ability. We have already found that the industrial assignments do stimulate application when the students return to the campus. In addition, students who do fail frequently find very satisfactory employment with their co-oping companies.

Recently we have been organizing for a fund-raising campaign of which I am the General Chairman. As such, I have been making special calls on the presidents of many of our large companies. It has been thrilling to find the welcome that I receive from them. Without exception, I have found them eager to give me all the time that is needed to thoroughly explain our program. I am confident that there will be a similar willingness on their part to contribute toward the development of what they refer to as a very interesting, new and refreshing approach toward the general problem of developing more highly trained and educated engineers in Canada. Certainly I hope this will be the case because we have a campaign objective of $4,750,000. Part of this will come from government, which brings me to another subject on which you might be interested in having the views of a Canadian.

Both the Provincial Government and the Federal Government are major contributors to the support of non-denominational universities in Canada. In spite of the fact that this has been going on for years, there has never been any attempt on the parts of government to interfere with the academic operation of the universities. We certainly hope that this academic freedom will continue, and there is nothing in our past experience which might lead us to fear government financial support as it is feared by some educators in the United States.

Summary

I will endeavour to quickly summarize our experience in introducing co-operative education in Canada as it relates to students, to the college, and to industry.

We have found that it does attract well-qualified students in sizable numbers. Many of these students are ones who would not otherwise continue their formal education. Consequently, we are not in main competing with other universities and we will be helping to increase the number of Canadian university graduates. The co-operative course and the general rapid expansion which it helps to make possible do provide an appealing challenge to well-qualified instructors. Consequently, we are confident that we will continue to procure good faculty members and maintain high academic standards. The interest that is being focused on the development of the co-operative course at Waterloo is giving the College a distinctive personality. We have never suggested that the co-operative system should replace the conventional system. We do believe that it serves a worthy purpose and that there is a need for it.

Canadian industry has quickly become enthusiastic for Waterloo's plan. They are accepting our students in spite of current recession problems. They are working out their own means of overcoming union problems that are involved in the acceptance of students.

As I mentioned previously, companies are coming to the campus in

increasing numbers. So far we have been able to place all of our students and we are confident that next year there will be more companies looking for students than we will be able to provide with students.

COOPERATIVE EDUCATION DIVISION BULLETIN

Charles F. Kettering— A Tribute

Adopted unanimously by members of the Cooperative Education Division, ASEE, January 9, 1959.

In his philosophy and his life work, Charles F. Kettering illustrated the best traditions of cooperative education. As a student and a young employee he anticipated the principles of cooperative training in his own early experience. As an engineer, inventor and director of research, he recognized the value of the cooperative plan and gave it his wholehearted support. In one of his latest utterances he said:

> If I were asked to make one most timely recommendation to Industry and Education, I would urge a national effort to double the activities of their cooperative programs within the next five years.

Never one to discount the findings of men trained in theory—and he used some of the country's best scientific brains in his research organizations—"Boss" Kettering made his own approach to problems in terms of concrete examples, which he discussed in homely everyday language. Concerning all proposed solutions to problems, whether these solutions originated in theory or not, he always asked, "How will they work out in practice?" Questions that prompted his personal investigations always arose in actual situations encountered in his experience. First he observed the need for an automobile starter—so that his friends would stop breaking their wrists in cranking operations—then he worked his way gradually to the invention that answered this need. It was the same with Ethyl gasoline and countless other useful contributions made by his Edison-like genius. To his inquiring mind, there were always other questions awaiting answers, such as "How can this machine be improved?" His insatiable curiosity was not lessened by the passing years. As he grew older his wide-ranging quest for truth and progress grew even more active and more intense.

To educators, industralists, business executives and all others who came under his influence, Charles Kettering was a source of inspiration and challenge. His perennially fresh and youthful enthusiasm gave him a special appeal to students and to those responsible for their training. As members of this last group, we acknowledge our indebtedness to the counsel and achievements of this truly great man and we recognize our responsibility for carrying out the ideas which he so convincingly advocated.

NIKOLA TESLA— LAST OF THE PIONEERS?

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It has been observed that a student might well complete his formal engineering education without ever having heard of Nikola Tesla. Yet, if we examine the record of engineering progress during the last half-century he is invariably associated with major developments in the electrical sciences. A Slav whose name has fallen somewhat dissonantly upon American ears, Tesla worked apart from the established engineering fraternities which would have helped to preserve a remarkable record of achievement. In tribute to Tesla for his outstanding accomplishments the International Electrotechnical Commission announced, on the eve of the world-wide observance of the Tesla Centennial Anniversary in 1956, that the unassigned unit of magnetic flux density in the MKS System be named in his honor. Introducing the new unit, "Tesla," Chairman Dunsheath conveyed the Commission's expression to the Centenary symposium held at Beograd (1) that, "By giving this great scientist's name to a unit of such extreme importance we have paid him the warmest tribute we can."

At the age of 31, Tesla announced a polyphase system of alternating current power transmission based upon his discovery of the rotating magnetic field principle. Alternating current had been known and used for lighting purposes, but the system had no motor. Essence of the Tesla System was an induction motor, a machine of ideal simplicity that did not require the costly and troublesome commutator of direct current machines. Alert to developments which would augment the company's entrance into the electrical domain, George Westinghouse immediately obtained exclusive rights to the Tesla patents and provided the polyphase system with its first practical demonstration in furnishing power for the Chicago Columbian Exposition of 1893.

Prior to this time an international commission had been established to survey the various possibilities of harnessing the power of Niagara Falls. Industrial America had begun to build on direct current power systems, which were fostered, developed, and given great impetus by Thomas Edison. On the basis of their operation, Lord Kelvin, heading the International Niagara Commission, favored direct current. It was an era of laissez-faire. Edison had issued the order that no electric power company with which he was associated would offer the alternating current system to the public. "My personal desire," wrote Edison, "would be to prohibit entirely the use of alternating currents. They are as unnecessary as they are dangerous" (2). However, the direct current systems had severe distance limitations, and in late 1893 the Tesla polyphase alternating current system was chosen on the basis of its incontestable merits.

By 1895 Niagara had been harnessed, giving birth to the great industrial power systems of the world. The polyphase system represented a most distinct advance in the electrical arts, there being few instances when

sweeping technological changes have been implemented so rapidly. Although the tides of development would have dictated the inevitable reduction of the rotating magnetic field principle, it had remained to Tesla to evolve a workable concept amidst the partial attempts and unsuccessful apparatus of other artisans. His contribution embraced the entire field of constant speed synchronous, induction, and split-phase motors, and was of such completeness that no basic changes have appeared in the system since its introduction, nor have any claimants been successful through the long history of litigation marking the Tesla patents.

Greener Fields

Although a promising success was predestined for the alternating current power system, Tesla did not choose to guide the new industry in its growth. Rather, having worked for one year with Westinghouse in Pittsburgh, he experienced so great a longing to resume his interrupted investigations that, notwithstanding the very tempting proposition offered, he returned to New York to again take up his laboratory work on the phenomena of alternating currents of vastly increased frequency and voltage. It is in this field where we find Tesla's name more familiarly associated, and the one invention which perhaps more than any other has served to perpetuate his name is the high frequency resonant transformer, or "Tesla coil." This piece of apparatus provided a means whereby high frequency currents could easily be generated and studied and was soon to be found in every experimental laboratory.

The first announcement of Tesla's researches came in 1891, when he began a trio-series of demonstration lectures delivered in America and in Europe to familiarize the public with his findings (3). The lectures themselves were literally brilliant, necessitating an array of special apparatus for the extensive repertoire of experiments. He showed to struck audiences that it is possible to pass relatively large amounts of high frequency current through the body with little sensible effect, and demonstrated for the first times high frequency induction heating, neon and fluorescent lamps, resonance and impedance phenomena, and methods of conversion to high frequency currents. Owing to pressing demands by several foreign scientific societies, he ventured to Europe, where he lectured twice in England and in France. On returning to America he appeared in 1893 before the Franklin Institute at Philadelphia and the National Electric Light Association at St. Louis. Tesla presented new concepts in the electrical art forming the nucleus of what has become the modern electronic age. In recognition of that pioneering lecture before its body, the Franklin Institute recently * adopted the Resolution,

Nikola Tesla stands with Benjamin Franklin in electrical achievements which have contributed much to the good of all mankind.

In his lecture before the Royal Institution of Great Britain, Tesla set forth technical arguments bearing on radio communication which had far-reaching implications. His lectures of the following year expanded upon those ideas to embrace the essential elements of antenna and ground circuits coupled with transmission and receiving circuits similarly tuned. The employment of an aerial conductor and ground connection was a feature not utilized by the contemporaries Lodge and Popov, nor employed by Slaby and Marconi until 1897, when their respective results were achieved.

* May 15, 1957, at a stated meeting honoring the Tesla Centenary.

Professor Slaby first acknowledged Tesla as the "Father of the Wireless" (4):

I have been engaged for some time in investigations in telegraphy without wires, which you have first announced in such a clear and precise manner in your "Inventions." It will interest you as the father of this telegraphy to learn. . . .*

Such a declaration precipitated others, but the discovery provided an opportunity for the application of multifarious "devices" which served but to detract from the basic work. In 1915 Tesla appeared again in the courts on fundamental issues, this time in an effort to prevent Marconi's attempt to establish a broad claim to all basic radio patents. Tesla's inability to obtain a favorable judgment had transcending effects upon the course of commercial radio development, and set a precedent for succeeding litigation involving other workers in the art. Tesla attributed his failure to the status of technical knowledge of the times, and to the unkind hand of fate; less than a year following Tesla's death the U. S. Supreme Court, in an historic but little noted decision (5), declared the Marconi "four tuned circuit" patents invalid on the basis of prior work and anticipation by Tesla and John Stone, the patents which had established Marconi as the master of radio.

New Vistas—Old Problems

With a conviction that alternating currents of tremendous magnitude would reveal novel and unsuspected properties, Tesla established an experimental station at Colorado Springs in 1899 unrestricted by the limits imposed in his New York City laboratory. There he discovered standing waves induced in the earth's static charge by impinging strokes of lightning which led him to generate such waves by artificial means and utilize the tremendous resonant action. Tesla produced electrical discharges surpassing in intensity those of natural lightning, an experiment which has not been duplicated since that time. Though the exact nature of the experiments conducted at Colorado Springs has not been completely disclosed, the basis for this grandiose research was to establish foundations in wireless power transmission. Returning to New York in 1900 he constructed a gigantic tower and power plant on Long Island to demonstrate in a practical way the results of these investigations, but mounting expenses unforeseen at the outset and a severe illness forced the abandonment of the project. The deserted tower and plant stood for many years as resolute landmarks of a bold dream—wireless power had not been practically demonstrated.

In contrast to the splendor of earlier projects, Tesla conducted in following years a comparatively retiring program of varied research activity. An important contribution from this period however was the application of a novel principle in mechanics to turbines and pumps. Dispensing with blading, the weakest element of a conventional turbine, the Tesla turbine has a rotor of closely spaced smooth discs to which energy is imparted by drag properties of fluid flow along logarithmic spiral stream lines. Following tests, Tesla remarked in a letter (6), "This result means an immense revolution in mechanics and there is scarcely a department which will not be profoundly affected." Notwithstanding the desirable characteristics of the spiral-flow turbine, it has not been developed commercially, although a revival of interest has oc-

* Ich beschaeftige mich seit laengerer Zeit mit der Erforschung der Telegraphie ohne Draehte, welche Sie zuerst in ihren "Inventions" . . . in so klarer und zutreffender Weise begruendet haben. Es wird Sie als Vater dieser Telegraphie interessieren zu hoeren. . . .

curred in recent years. The inherently high rotational speed imposed restrictions on its initial application and construction, and Tesla's financial inability in later years to undertake the development task himself also contributed to its present obscurity. The day of the lone pioneer and wealthy patron had passed, and for Tesla the adjustment to working with a developmental staff was untenable.

The past half-century of engineering and scientific progress has brought with it a marked change in processes of development. As a classical symphony did not emerge by group effort, neither were the achievements of early pioneers in science the product of a research staff. So interwoven have become the concerted efforts directed toward common goals that personalities *per se* are no longer forerunners in the advancement of the art. Tesla was perhaps the last member of that society of "true pioneers," but whether the new pattern of scientific research will provide a new breath of life to discovery only future reflection will tell. In nearly all instances Tesla was unable to profit directly from his work, the advanced nature of which restricted immediate and practical utilization, but through private support he was able to conduct a program of research activity greatly exceeding the financial bounds of many other groups. His creativity seemed limited only by the ability of one man to advance alone and develop new principles. Though perhaps giving freer vent to the expression of his ideas, it is clear that such isolation prematurely retarded later successes.

Tesla passed on January 7, 1943, in the quiet of a remarkably brilliant career. The concept of the rotating magnetic field as applied to the polyphase system of alternating current power transmission is a lasting monument to his inventive genius. In all the literature of high frequency phenomena, perhaps none has stirred the imagination so much as his writings. The work of this prolific savant whose life was so intimately dedicated to the enrichment and betterment of mankind through discovery is indeed an inspiration in these times.

References

1. Motivated by the observance of the Tesla Centenary throughout the world, the Nikola Tesla Museum has published in English the anniversary volume, "Nikola Tesla, 1856–1943; Lectures—Patents—Articles." 830 pages, Beograd, 1956. Included are five of the most important lectures delivered by Tesla in America and Europe, complete facsimile drawings and specifications of his major patents, and twenty-five articles on science and philosophy written by him between 1891 and 1917.
2. Thomas Edison, "The Dangers of Electric Lighting." *North American Review*, November, 1889, page 632.
3. "The Inventions, Researches and Writings of Nikola Tesla" with special reference to his work in polyphase currents and high potential lighting, by Thomas Commerford Martin. 496 pages, The Electrical Engineer, New York, 1894. (Reproduced as contribution to the electrical industry by the Lee Engineering Co., Milwaukee, 1952.) Includes the three lectures by Tesla on the phenomena of high frequency alternating currents delivered during 1891, 1892, and 1893.
4. Professor A. Slaby in a letter dated December 1, 1898, to Tesla. Original in Nikola Tesla Museum, Beograd.
5. "United States Reports," Vol. 320. Cases adjudged in The Supreme Court at October term, 1942, and October term, 1943.
6. Nikola Tesla in a letter dated October 13, 1908, to his private secretary. Original in collection of writer.

MACHINE DRAFTING—ON THE WAY

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Senior Engineer
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Singer Manufacturing Company,
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This article was written several years ago while the author was doing graduate work in Industrial Engineering at The Pennsylvania State University; while extensions of the work have been made, the viewpoint expressed is of sufficient interest for publication at this time.

As a new industrial process, machine drafting has been given serious consideration by several industries. A review of the proposal may aid engineering educators in long range planning of drafting course work. This being a new idea, perhaps an explanation is in order. Machine Drafting is conceived to be a system of production of drawings through selection of commands from a control panel to a desk operated machine. Thus, for a 2″ horizontal line to the right, selection is made of the proper dimensions and direction command for execution of the line. Circles, arcs, and other components are executed similarly.

Mechanical elements and devices were originally planned for the movement and control of the stylus over the drawing paper, but developments in the field of servomechanisms have presented a more elegant way to perform some of the operations required. It is now quite feasible to feed a formula into a suitable computer and get a trace or drawing on an output device such as a plotting board or drum. But this is not viewed as the first step. The problems of drafting are unique, and development would have to start with the problems of drafting and not with the job of solving a mathematical equation.

In a recent unpublished study on "The Application of MTM Standards in the Drafting Field," by the writer (supervised by Dr. C. A. Anderson, Prof. of Industrial Engineering, Penn State University), it was recognized that the general term "drafting" needed two explicit categories for the variable "thought" time required. The following definitions were arbitrarily adopted:

Straight Drafting: The execution of engineering drawings wherein all the information is supplied, is accessible in handbooks, or is accepted as part of the stock-in-trade of the draftsman.

Design Drafting: The development of engineering drawings requiring, in addition to the routines of straight drafting, exercise of creative thought processes plus employment of an indeterminate sequence of engineering technology.

In discussions of Machine Drafting, some reviewers cite drawings that would indeed be difficult and costly for a machine to produce. Drawings such as these, with many irregular lines, are not seen as immediate applications for Machine Drafting. Neither is design drafting work. Rather, the development is felt to have an application primarily for straight drafting work.

Fundamentally, we must recognize drafting as a kind of language. We use it as a practical (and technical) convenience for the communication of ideas and instructions in the engineering world. All else is trimming.

Viewed as an accounting item, drafting is an expense or overhead operation. We should not fail to realize that a drawing only adds to the value of an industrial product as an aid in the manufacturing process.

Because drafting work is performed in almost every industrial effort, one can readily appreciate the expense and investment involved. Simplified drafting (as now practiced by companies such as American Machine & Foundry, General Electric, and others) results from the desire to reduce the cost and time investment. This trend toward simplified drafting solves many of the problems thought formidable to the development of machine drafting.

The author is not suggesting that drafting as an engineering course is or should be on the way out. The training in spatial relationships that drafting provides is extremely important in helping the student engineer think in a three-dimensional field. To be able to draw and letter neatly is also an asset; but this is more a matter of degree. This is particularly true in view of the growth and diversification of the profession. One chief engineer recently stated to me that he would rather *not* have an engineer for his board work—not because the engineer is overqualified, but because the draftsman or engineering aid was more familiar with board techniques and could produce better layouts and designs.

Over the past years, a controversy appears to have developed over the content and value of drafting courses. Some of the recent industrial developments are deciding the issues for the campus. Simplified drafting, for example, is forcing a change in subject matter; machine drafting could do likewise. We might revise the old chestnut, "When in Rome, do as the Romans do," to "when methods change, grow with them." A considerable amount of thought has been given to the problems of machine drafting. Any development that may eventually be undertaken would require the combined talents of many fields. The author would welcome the receipt of source data on this problem, either from industry or from colleges. Comments are also invited on the whole proposal. The facts are simple; drafting is a job—when there's a more economical way to do it, industry will get behind the development, and drafting instruction will follow suit.

FOUNDATION ANNOUNCES GRADUATE AND POSTDOCTORAL FELLOWSHIP AWARDS

The National Science Foundation has announced award of 1,100 Graduate Fellowships in the natural sciences and allied fields for the academic year 1959–1960. Successful Fellows were selected from 4,506 applicants from all parts of the continental United States and its territories. The Foundation also released names of 1,979 persons accorded Honorable Mention. Of the 1,100 Fellowships awarded, 175 were in engineering.

DETERMINING THE RESPONSE DUE TO A RANDOM EXCITING FORCE

BAYARD E. QUINN

Professor of Mechanical Engineering
Purdue University

Recommended by the Engineering Graphics Division

With the advent of the jet engine and rocket motor there has been considerable interest in the response of various components to random exciting forces.

A typical random exciting force-time record is shown in Figure 1(a). A record of this type is frequently characterized by a power spectral density analysis. This analysis is based upon the statistical properties of the record (autocorrelation function) and many references are available that deal with this subject. The results of a power spectral density analysis are usually presented in the form of a curve. In Figure 2 the curve indicated by $f(\omega)$ is the power spectrum of the record shown in Figure 1(a). The ordinate is in units of lbs.^{2}/cps. and is plotted against frequency in cps. Curves of this type are often supplied to vendors to describe the environment that a component must withstand.

In Figure 1(b) is shown the linear, damped system that is frequently used to characterize a component or a structural member. This system is excited by the random force $F(R)$. If the response of the system is considered to be the displacement x, then x will also be random in nature and will have associated with it a power spectrum curve; the area under which will represent the mean-squared value of the resulting displacement. It will be seen that the frequency range of this curve will be limited to a narrow band of frequencies distributed around the resonant frequency of the system.

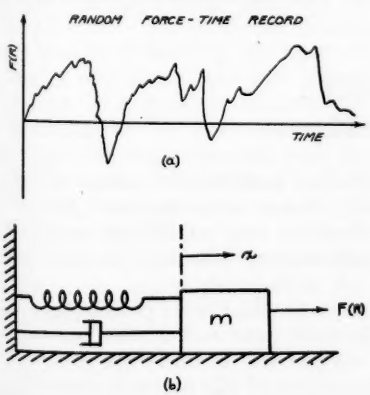

FIG. 1.

The mean-squared response $\bar{x}^2$ is given by

$$\bar{x}^2 = \int_0^\infty \frac{f(\omega)}{|z(\omega)|^2} d\omega, \qquad (1)$$

where $f(\omega)$ is the power spectrum of the random exciting force and $\frac{1}{z(\omega)}$ is the *steady-state sinusoidal* response of the system to a *steady-state sinusoidal* exciting force. This can be determined mathematically or experimentally and is thus readily available.

It is possible to evaluate the integral in equation (1) by using a very simple graphical procedure that will yield not only the numerical value of $\bar{x}^2$ but also the power spectrum of the displacement x. It is also possible to observe the effect on $\bar{x}^2$ of changing the natural frequency or the amount of damping in the system.

The power spectrum of the random exciting force $f(\omega)$ is plotted as shown in Figure 2. Since the function $\frac{1}{z(\omega)}$ of

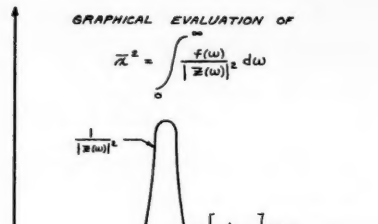

FIG. 2.

the system is available it is possible to plot $\frac{1}{|z(\omega)|^2}$ as a function of frequency. This quantity will have the units of inches²/lbs². and the resulting curve is shown by the solid line in Figure 2. The product $\left[\frac{1}{|z(\omega)|^2}\right] f(\omega)$ is formed by multiplying the corresponding ordinates of the curves at a selected frequency. If this is done at several frequencies the dotted curve in Figure 2 will be obtained. This curve describes the *power spectrum* of the displacement x and has the units of inches²/cps. Equation (1) indicates that the area under this curve is the value of $\bar{x}^2$, hence by using a planimeter (or other appropriate procedure) the mean-squared value of the displacement can be obtained.

It is thus evident that by using the simplest of graphical techniques it is possible to obtain the response of a system to a random exciting force. This response is described in terms of the power spectrum and also by the mean-squared value of the displacement.

By referring to Figure 2 it is easy to see that decreasing the natural frequency will move the solid curve to the left. Since each ordinate of the solid curve will therefore be multiplied by a smaller value of $f(\omega)$ the value of $\bar{x}^2$ will be reduced. Because increasing the damping will reduce the ordinates of the solid curve it can be seen that a reduction of $\bar{x}^2$ will likewise occur if damping is increased. The graphical solution of the integral thus makes it easy to estimate the effect upon the response of changing the characteristics of the system.

A very simple graphical technique can thus be used to solve a problem that may be very complex in nature. It should be observed however, that all curves have been plotted using rectangular coordinates to represent power spectral density analyses.

INDIAN INSTITUTE OF SCIENCE CELEBRATING GOLDEN JUBILEE

Beginning February 2, 1959, the Indian Institute of Science, at Bangalore, is celebrating its Golden Jubilee. Founded in 1909 through the efforts of N. Tata, the Institute was established as a post-graduate institution for the promotion of advanced studies and original research.

The Institute, the first of its kind in India, has been a pioneer in advanced instruction and research in both pure and applied sciences, including engineering. The work of the Institute has contributed substantially towards the promotion of the national economy of India.

THREE DIMENSIONAL REPRESENTATION OF MECHANICAL VIBRATION CHARACTERISTICS

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This paper is concerned with the vibration characteristics of a single degree of freedom system. The system consists of a mass linked to a rigid base by means of a linear spring and a viscous damper and excited by a force $P_0 \sin(\omega t)$ applied to the mass. Steady state conditions are assumed to exist.

When a student first studies the vibration characteristics of the above system, he is confronted with the task of assimilating the effects of three variables. The variables are amplitude, frequency and phase angle. The relationships which exist between these variables are generally presented as amplitude ratio vs. frequency ratio, phase angle vs. frequency ratio and amplitude ratio vs. phase angle.

One misleading feature of the two-dimensional plot of amplitude ratio vs. frequency ratio results from the manner of portraying the data for the condition of zero damping. In this case vibration texts indicate the 180° phase shift by plotting the curve above resonance as originating at $-\infty$. However, with a small amount of damping, the curve is shown as originating near $+\infty$ above resonance. This apparent inconsistence is eliminated by the three dimensional plot where all values for zero and for negligible damping originate at or near $+\infty$. The phase shift for this plot is the third dimension.

The following equation describes the motion of the system described in the first paragraph

$$m\ddot{x} + c\dot{x} + kx = P_0 \sin\omega t. \quad (1)$$

The steady state solution for the amplitude of the motion of the mass is[1]

$$X_0 = \frac{P_0}{\sqrt{(k-m\omega^2)^2+(c\omega)^2}} = \frac{P_0/k}{\sqrt{\left(1-\left(\frac{\omega}{\omega_n}\right)^2\right)^2+\left(2\frac{c}{c_c}\cdot\frac{\omega}{\omega_n}\right)^2}}. \quad (2)$$

The steady state solution for the phase angle ϕ between the excitation force P_0 and the amplitude, X_0 is

$$\tan\phi = \frac{c\omega}{k-m\omega^2} = \frac{2\frac{c}{c_c}\cdot\frac{\omega}{\omega_n}}{1-\left(\frac{\omega}{\omega_n}\right)^2}. \quad (3)$$

In Eq. (2) and (3)

$$\omega_n = \sqrt{k/m}, \quad c_c = \sqrt{4mk} = 2m\omega_n. \quad (4)$$

Now let the static deflection

$$= X_{st} = P_0/k. \quad (5)$$

From Eq. (2) and (5):

$$\frac{X_0}{X_{st}} = \frac{1}{\sqrt{\left(1-\left(\frac{\omega}{\omega_n}\right)^2\right)^2+\left(2\frac{c}{c_c}\cdot\frac{\omega}{\omega_n}\right)^2}}. \quad (6)$$

The elimination of (ω/ω_n) between Eq. (3) and (6) yields

$$\frac{X_0}{X_{st}} = \frac{\cos\phi}{2} + \sqrt{\frac{\cos^2\phi}{4} + \frac{\sin^2\phi}{(2c/c_c)^2}}. \quad (7)$$

Equation (7) may also be expressed in terms of the $\cos\phi$ and the $\tan\phi$ but in this case it is not valid at $\phi = 90°$.

If Eq. (3) is solved for its right hand denominator and the square of this term

[1] *Mechanical Vibrations* by J. P. Den Hartog, 4th Edition, 1956, McGraw-Hill Book Company, Inc., New York, New York.

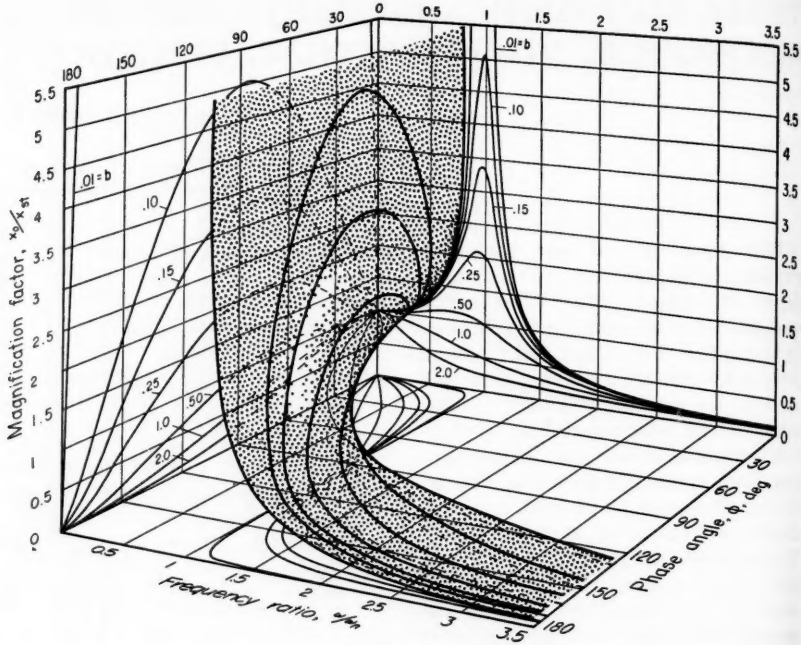

FIG. 1.

is used to replace the left hand term under the square root in the right hand denominator of Eq. (6), the following equation is obtained after simplifying:

$$\frac{X_0}{X_{st}} = \frac{\sin\phi}{2\frac{c}{c_c}\frac{\omega}{\omega_n}}. \tag{8}$$

Eq. (8) is the equation of the lines of constant damping (c/c_c), on the space sheet or surface in the three dimensional plot.

The equation of the space surface is obtained by solving Eq. (3) for the right hand numerator, squaring this term and using it to replace the right term under the square root of Eq. (6). Simplifying, the following result is obtained.

$$\frac{X_0}{X_{st}} = \frac{\cos\phi}{1-(\omega/\omega_n)^2}. \tag{9}$$

The usual plots of Eq. (3), (6), and (7) appear in the three dimensional plot as the ϕ vs. (ω/ω_n), the (X_0/X_{st}) vs. projections. The lines on the space surface represent Eq. (8), while the surface is represented by Eq. (9). All lines on the surface pass through a vertical erected from the horizontal plane through $(\omega/\omega_n) = 1$ and $\phi = 90°$. That is, the phase shift is 90° at $(\omega/\omega_n) = 1$ for all values of (c/c_c). The numbers on the (X_0/X_{st}) vs. (ω/ω_n) and the (X_0/X_{st}) vs ϕ plots represent various values of $(c/c_c) = b$.

The space plot presented here has been used for the past eleven years in explaining the above phenomenon. A wire model approximately twelve inches in length in each of the three directions was first prepared with plywood boards making up the base and the two vertical portions of the model. Later, a three dimensional drawing, Fig. 1, was prepared by Stephen W. Gilbert with the cooperation of Professor Clifford H. Springer of our General Engineering Department.

According to Professor Karl Klotter of Stanford University, this type of plot appeared in some of the electrical circuit papers in Germany about 1920.

Mr. Dean C. Broughton used a model such as the above while teaching mechanical vibrations courses at Syracuse University and found it to be a good visual aid. Professor Laurence E. Goodman has used such a model at the Institute of Technology, University of Minnesota and has found it to be helpful.

SURVEY OF UNDERGRADUATE HEAT TRANSFER TEACHING FOR MECHANICAL ENGINEERS

ASME Committee on Teaching of Heat Transfer (k-15)

F. Landis (*Chairman*)
K. N. Astill
C. H. Coogan
H. G. Elrod, Jr.
H. K. Hurwicz
S. P. Kezios
E. B. Penrod
W. M. Rohsenow

A survey of undergraduate heat transfer courses offered for mechanical engineering students was conducted during 1957 by the Committee on Teaching of Heat Transfer, Heat Transfer Division, ASME under the direction of Prof. C. H. Coogan of the University of Connecticut. The primary purpose of this survey was to establish how far the teaching of heat transfer as an engineering science had penetrated into the mechanical engineering curriculum and to evaluate the likely direction which such programs would assume.

Although the committee realizes that any listing of curricula covering the academic year 1956–1957 is likely to be somewhat out-dated at this time, it is believed that the general results would still be of interest to ASEE members.

Questionnaires were sent to all engineering colleges with accredited mechanical engineering programs and 80 replies were received, representing the majority of the institutions canvassed. For purposes of analysis, a distinction was made in the questionnaire between the incidental teaching of heat transfer applications as would occur in power plants or air conditioning courses and the systematic teaching of heat transfer fundamentals in any course (irrespective of course title) provided at least 1½ term credit hours were devoted to heat transfer.

The results of the survey are summarized in the table below. Over half the responding institutions required at least a three term credit hour (or equivalent) course in either the junior or the senior year. A first course in thermodynamics was a prerequisite in almost all instances, and a considerable number of schools also required a previous course in differential equations. Where heat transfer was offered as a senior course, fluid mechanics was frequently listed as a prerequisite.

The listing of "Regular Electives" includes courses which would be taken by a sizable portion of the mechanical engineering student body and which may be required for certain M.E. options.

Course content followed, in general, the standard textbook coverage of conduction, convection, radiation, and

SUMMARY OF UNDERGRADUATE HEAT TRANSFER TEACHING IN MECHANICAL ENGINEERING—1957

Course Offerings	No. of Schools
Required Heat Transfer Courses	
2 Term Credits or Equivalent	14
3 or 4 Term Credits or Equivalent	43
3 Term Credits Plus Senior Elective	2
Regular Electives	
2 Term Credits or Equivalent	1
3 Term Credits or Equivalent	10
No Heat Transfer Course Offered or Less than 1½ term Credits	8
Total	80

TEXTBOOK USED AS OF 1956–57

	No. of Schools
Brown and Marco, "Introduction to Heat Transfer"—McGraw-Hill	23
Jakob and Hawkins, "Elements of Heat Transfer and Insulation"—Wiley	21
McAdams, "Heat Transmission"—McGraw-Hill	16
Giedt, "Principles of Engineering Heat Transfer"—Van Nostrand	8
Others and Notes Only	5

heat exchanger analysis, although transient conduction was omitted in some schools. Only in isolated cases was mass transfer incorporated as part of the course.

The 1956–57 textbook requirements are also shown in the table (some schools indicated more than one required text). These listings should not be considered to indicate trends; the survey was carried out prior to publication of either Kreith's text or the revised editions of "Brown and Marco" and "Jakob and Hawkins," and during the first year of publication of Giedt's book. It should, however, be added that a relatively large number of respondents expressed dissatisfaction with the texts they used at the time of the survey and indicated a desire to switch to a more thorough or advanced undergraduate text as soon as it became available.

Most schools also listed separate heat transfer offerings in chemical engineering, either as a separate course or as part of a unit operations sequence. Approximately half the respondents listed heat transfer as an elective for non-mechanical engineers, although less than a dozen required such a course for either electrical or aeronautical engineers. Three schools indicated a separate heat transfer course as a requirement in electrical engineering.

Additional information regarding this survey may be obtained by contacting Prof. F. Landis, Dept. of Mechanical Engineering, New York University, New York 53, N. Y.

FOUR MORE YEARS OF THE DRAFT (*Continued from page 920*)

in the event of an international emergency.

These are the rules and regulations of greatest concern to students and the members of the academic profession. Liberal as they are, they rightly place a premium upon good scholarship or useful employment in fields considered essential to the national welfare. Although it was hoped that teaching and research might be deemed so critical as to be acceptable substitutes for service in uniform, the importance attached to them and to study in these fields is evident from the liberal manner in which the rules and regulations are administered within the Draft Law.

ELECTRICAL DIVISION NEWSLETTER

Since the luncheon meeting of the Electrical Division at Berkeley, the officers of the Division have been busy arranging for the details of the E.E. sessions at Pittsburgh. In addition, possible future activities that might be of interest to our group have also been under consideration. This newsletter is intended to bring the members of the Division up-to-date on the progress so far.

1. There are five activities planned for the Annual Meeting in Pittsburgh which have been arranged particularly for members of the Electrical Division. On Monday evening, June 15, at 8 P.M. there will be an informal discussion session to allow those electrical engineers in attendance to get acquainted and contribute their thoughts with regard to the future activities of the Division. Formal sessions have been arranged for Monday morning, for Tuesday and Thursday afternoons, and for all day Wednesday. Full details of these sessions can be found in the preliminary program.

2. The Annual Business Meeting of the Electrical Division will be held at noon on Thursday. At the meeting, the election of officers will take place, and details of proposed future programs will be presented for consideration by the members of the division.

3. A Nominating Committee has been appointed to prepare recommendations for Division officers for the year 1959–1960. The chairman of the Committee is Dean J. Stuart Johnson, Wayne State University, Detroit, Michigan. Other members of the Committee are Dean T. L. Martin and Professor A. G. Conrad. Members are urged to send recommendations to the chairman of the Committee for consideration.

4. The Electrical Division has arranged a follow-up meeting to the MIT E.E. Curriculum Workshop to be sponsored by the National Science Foundation. The meeting is to be held at Case Institute of Technology from August 31 to September 4, 1959. Provisions will be made for one representative from each ECPD accredited E.E. department to attend this Conference. Details on the meeting will be provided in the near future. Professor Samuel Seely is General Chairman of the event.

Officers of the Division

Chairman	Professor Austin V. Eastman Executive Officer Department of Electrical Engineering University of Washington, Seattle, Washington
Vice Chairman	Professor James H. Mulligan, Jr. Chairman, Department of Electrical Engineering New York University, New York 53, New York
Secretary	Professor Warren B. Boast Head, Department of Electrical Engineering Iowa State College, Ames, Iowa
Representative on General Council (1957–59)	Professor Samuel Seely Head, Department of Electrical Engineering Case Institute of Technology, Cleveland 6, Ohio

CIVIL ENGINEERING DIVISION

Chairman's Message

The Civil Engineering Division has been offered the opportunity to submit its views on pertinent matters in a Civil Engineering Bulletin in the JOURNAL. It is hoped that this inauspicious start will encourage members of the Division to submit ideas and short articles of general interest to the Division Secretary and Editor, Professor George R. Shaw, Rensselaer Polytechnic Institute, for publication consideration. Immediate offerings will have little competition! In effect, this page will probably take the place of the former separate Civil Engineering Bulletin which so nicely served as a medium for papers too long or too specialized for the JOURNAL. Unfortunately, lack of funds obtained from advertisers and loss of an advantageous printing and mailing arrangement for the Bulletin forced its discontinuance.

Bylaws of the Civil Engineering Division were amended at the Berkeley meeting in June, 1958, and brought up-to-date by Professor B. A. Whisler, past chairman of the Division. One of the newer requirements of the bylaws covers the nomination and election of officers as follows:

"A Chairman, Vice Chairman, and two Directors shall be elected each year. A Secretary shall be elected every third year. The officers will take office at the close of the annual meeting in June.

"The new Chairman shall appoint a Nominating Committee consisting of three members of the Civil Engineering Division at the annual meeting of the Division. This Committee shall report its nominations to the Chairman by September 30, and these nominations shall be promptly published in the JOURNAL OF ENGINEERING EDUCATION and in the Bulletin of the Division if the latter is published. Additional nominations may be made by petition signed by ten members in good standing and directed to the Chairman within thirty days after the nominations are first published.

"If no additional nominations are received for any office, any single candidate shall be considered to be unanimously elected to office by the Division. If more than one candidate is nominated for any office, the Secretary shall prepare mail ballots and send them to all members of the Civil Engineering Division in good standing. Completed ballots shall be returned to the Secretary of the Division who will canvass them thirty days after the original mailing and report the results to the Chairman."

A nominating committee was appointed at the Berkeley meeting by the present Division chairman but an "oversupply of confusion" and other reasons delayed receipt of the nominations until just no... Nominations made by the Nominating Committee (composed of three past chairmen of the division) for vacancies to be filled at the annual meeting in June are as follows:

For Chairman	Dean Lewis K. Downing, Howard University
For Vice Chairman	Professor F. B. Farquharson, Univ. of Washington
For Director	Professor M. E. Bender, Colorado State U.
For Director	Professor R. E. Kolm, Lehigh University

It is now too late to send mail ballots covering possible contested offices, but nominations in accordance with the provisions of the bylaws are welcomed. Elections will be held at the Luncheon and Annual Business Meeting, Tuesday 16 June, and the composite list of nominees, plus any offered from the floor, will be voted upon.

The Civil Engineering Division has been one of the "meetingist" divisions of any in ASEE since its formation. In the past few years, a successful attempt has been made to reduce the number of meetings and papers by having the eight Committees schedule only four sessions, two Committees participating in each session. This avoids some conflicts of interest resulting from simultaneous divisional programs and also permits attendance at other Society affairs. It is hoped, however, that doubling up on sponsoring committees will not eliminate one of the most valuable features, time for open discussion in the sessions.

Dean Lewis K. Downing has arranged an interesting program for the June meeting. For the first time, a full day for field trips is included in all divisional arrangements. Let us keep the Civil Engineering Division one of the most active groups in the Society and be on hand in Pittsburgh to discuss a critical point that personal correspondence has shown to be highly controversial: Is Civil Engineering Education Properly or Improperly Being Forced Into the Same Pattern as Other Engineering Curricula Which May Have Different Objectives?

CANDID COMMENTS

This section is open to those of our readers who have brief comments to make on articles in the JOURNAL or on engineering education in general. Send your comments to the Editor, JOURNAL OF ENGINEERING EDUCATION, University of Illinois, Urbana, Illinois.

On "I Accuse"

The January issue of the JOURNAL carries an article by J. M. F. Vickers with the rather trite title "I Accuse." Not only does the article fail, in its content, to justify its sensationalistic title, but proper logic, reasoning, facts or other evidence is conspicuously absent from it.

The question of graduate student motivation has plagued educators for many, many years, but has to this date successfully resisted an adequate explanation. The answer must certainly be a complex combination of at least a half dozen factors. The relative ease with which the author has solved the problem by attributing the lack of student desire for advanced training to two clearly defined, independent factors is commendable, but, I fear, is a gross oversimplification. Not only does the proposed explanation seem naive, but since the two phenomena are claimed to have arisen in recent years, what could the explanation have been prior to "recent" years?

The author first claims that specialization of courses is increasing. On the contrary, there is ample evidence in recent issues of the JOURNAL, and in the catalogs of the majority of the engineering schools, that the degree of specialization in the various curricula is very definitely on the decline. The tendency is no longer toward the creation of professional courses of great detail and narrow scope, but toward greater emphasis on the fundamental concepts and their interrela-

tion. The latter idea is particularly important with respect to the type of person best qualified to teach it, which leads to my criticism of the author's second major point.

I should like to interject, at this point, my belief that I am safe from the charge of prejudice in this discussion since I do not fit into any of the stereotyped classes mentioned by the author. I am certainly not an expert, and my age precludes the possibility that I have degenerated into a "pseudo-expert." I am not a "professional" author, nor even an amateur one, never having written a book of any kind. Finally, I will not admit to being a "jack-of-all-trades," since there are many areas of engineering to which I plead ignorance. However, the "jack-of-all-trades" is not deserving of such a condemnation as the author has given him. Is there anything inherently bad about an engineer with broad interests and experiences? Is it not precisely this type of person that is so wanted in engineering areas of overlapping conventional disciplines, such as nuclear engineering and "space" engineering?

Every engineering teacher has encountered textbooks which he has considered inferior. No one can deny that there are many such books. But the writing of bad books is not the exclusive province of the "professional author." One can certainly point to at least as many bad books written by so-called "experts." The claim, in sweeping generality, that all of the books of the prolific authors are without quality, is entirely without foundation. Many of the fine books of our times have been written by gifted people with the ability to produce excellent material in several fields. One need only mention a few names like von Karman, von Mises, Southwell, Timoshenko, Den Hartog and Glasstone, to prove the point. On the contrary, in the field of mechanical engineering, I know of only one "professional author" fitting the author's description. Why, then, heap abuse upon a class of people because of only one or two particular members? And how could this conceivably affect students' graduate training motivation? Students are exposed to a small number of texts, some of which may be bad, but how are they to know that the field is "flooded" by inferior textbooks? A bad book is a bad book, regardless of who wrote it. The selection of such a book for a course reflects only on the instructor, not on the author.

I would like to ask the author whether he has developed his ideas from a discussion with a handful of students, at one school, in one department? Has he had a disappointing experience with one or two textbooks? The answers are really not important. These are the impressions which the article creates and it is in this light that the ideas are evaluated. If the author has a more substantial case, he has done himself a grave injustice by not properly presenting it.

The author of "I Accuse" has, in my opinion, made some severe and unfounded accusations. I sincerely hope that this or some other communication with similar views will find its way into the pages of the JOURNAL.

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Attitude in Teaching Engineering Design

The JOURNAL for January, 1959, contains, at pp. 358, 359, and 365, a contribution by Professor Joseph C. Osborn of Lehigh on student improvisations in calculations, in relation to a simple engineering mechanics problem, Problem 109 in Timoshenko and MacCullough's *Elements of Strength of Materials*, which deals with the

elongation of a uniformly tapering vertical bar under an axial load. The citation below the title says, "Most of us have met this problem or similar ones in our teaching but probably have not taken the time to analyze the problem as completely as Professor Osborn has analyzed it. His comments should be interesting to most teachers of engineering mechanics." They have also been of interest to the present writer, who, however, approaches the matter from a somewhat unusual angle, being essentially a "materials' man" and having been brought up in the British rather than the American tradition of what constitutes "the engineering approach," as well as with the British concept of correct student/teacher relations in the universities.

It is from these viewpoints that the following comments are made:—

i) The statement of the problem: "Determine the elongation of a uniformly tapering bar, suspended vertically, caused by a load of 10,000 lb. at the lower end. The bar is 100 in. long; the diameter of the upper end is 2 in. and of the lower end is 1 in. Use $E = 30 \times 10^6$ p.s.i. and neglect the weight of the bar. Answer: 0.0212 in." contains an answer, but the problem is, in fact, incapable of solution by elastic theory, or otherwise, without special assumptions. It seems to have been assumed by the professor and his students that the instruction "use $E = 30 \times 10^6$ p.s.i." defines the material of the tapered bar as a steel at the ordinary temperature, and further assumed by them that the limit of proportionality can therefore be taken to exceed the maximum applied stress, $40{,}000/\pi$ p.s.i. or approximately 12,700 p.s.i., but the writer is prepared to produce at short notice (and on payment of reasonable expenses) samples of a variety of metallic materials with $E = 30 \times 10^6$ p.s.i. (at certain defined temperatures) but which would suffer permanent deformation (at those temperatures) below 12,700 p.s.i. For all such materials the assumption of perfect elasticity would be invalid.

It may be claimed that this argument is a quibble, but the writer would assert that engineers have too long made indefensible assumptions about their materials, and in particular have been too eager to assume that steel may be taken as typical of all metals and that metals exhibit generally the behavior to stress of an idealized isotropic elastic continuum, despite abundant evidence to the contrary, especially in the case of underdeoxidised low-carbon steel—the material traditionally used by engineers in the largest tonnages which derives its most characteristic feature, its yield point, precisely from its non-uniformity of behavior under uniform applied stress. In the nuclear age, the Sputnik age, or whatever other age we have now entered, the engineer must be prepared to use a wide variety of materials over a wide range of temperatures, and the less the number of ill-founded generalizations he makes the better for all of us. One example which he can readily avoid is the assumption that engineering mechanics calculations refer to unformly deforming specimens of steel, unless the contrary is stated.

ii) The student is represented as making three stabs in the dark to reach the stated answer to the problem, and as believing that as soon as he has found a drill which gives the stated answer he has "solved the problem," though he cannot defend his method of computation. It is agreed with Professor Osborn that the teacher has a general duty to reject unexplained solutions, but pointed out that there are high-IQ students who would defend the method used in stab III, by the argument that the combined effect of two quantities whose in-

dividual contributions are as their squares, cannot be other than dependent on the geometrical mean.

The main faults committed by the student seem in fact to be: 1) being led on by the answer—a complication which would have been avoided had the answer been omitted. It reminds one of the story in Boswell's *Life of Johnson* about the Scottish judge who was just about to sentence a thievish servant when he found that the coins stolen had been deliberately placed, as a trap, by the servant's master, so he sent the master to prison! 2) not understanding the principle involved, which is that the over-all elastic extension of a bar of non-uniform section, or one subjected to varied force, may in general only be properly derived by summing the individual extensions of transverse elements into which the tapered bar may be divided.

This is one of many problems which can be set up which are soluble on the latter basis, but one of few to which the "right" answers may be reached by assessing the elastic response to an averaged stress. Any method of solution, whether by calculus, tables, nomograms, graphical methods or other means, which takes this principle into account should be acceptable, and is to be preferred to any computation which is intuitive; no one method such as the use of calculus can be fairly described as a "master discipline."

iii) The calculus computation offered by Professor Osborn, like the student's third stab, has the merit of arriving at the "right" answer, without demonstrable mistake, but it seems to the writer to be open to criticism on two scores: that it does not include a statement of method, and that it is laid out in a way that does not make it quite clear that extensions are being summed and an effective area is not being calculated. Moreover, no point can be seen in the professor attacking a more complex problem than that set, and moving from a uniform taper to the case of a "smooth taper," when the expression "uniform taper" in the problem clearly implies that $A = Ky^2$. The writer is unaware of any special interest in the particular type of semi-generalized solutions offered by Professor Osborn. He further confesses to being confused by the author's apparent implication that the power formula he uses, $A = Ky^n$, covers a "general case," whereas smooth tapers may obviously involve more complex curves than this simple power function. One wonders what comment a student presenting such solutions would invite; perhaps he would be told that the solutions for cases other than $n = 2$ were unsolicited demonstrations of virtuosity.

iv) Students who had tried the improvised methods of solution are criticised for demanding of the teacher "Why doesn't it work?" or "What's wrong with this method?" Professor Osborn says: "Either question is a snare and a trap for the teacher and, in order to retain or obtain the student's admiration, he may succumb to the temptation to answer the question, 'Why not?' If he does so, he has not only gone beyond the call of duty, but he may have reinforced the student's belief that the question 'Why not?' is appropriate."

The present writer has overcome his natural hesitation to pointing out that in Britain expression of these sentiments by an engineering teacher would be regarded categorically as inappropriate, and it is questioned whether they represent an attitude common in the United States. The job of a "teacher" is surely to "teach" and "teaching" often needs to proceed by dispelling misconceptions, rather than by mere didactic display of a teacher's knowledge. It may sound

altruistic, but the writer would say that to the true teacher, *nothing* is beyond the call of duty, and he feels that no one ought so to describe a simple matter such as explaining that in order to obtain an acceptable answer the student must follow an intelligent and intelligible process, or that solution of this type of problem needs to be sought by summing elastic extensions of elements and *not* by calculating an effective load-carrying cross-section.

Professor Osborn ends by drawing attention to the fact that "it is the intellectual discipline which is important" which "has a wide range of applicability." This is a view which the writer would also emphasize, and he would additionally believe it to be his duty to focus students' attention on "master disciplines," even if he had to prepare the way for them by challenging views that had previously been held by the students. In this particular field, however, where the problem and its answer have little reality, he would try not to exaggerate the status of any method of calculation. He feels further that a conscientious teacher would continually warn students of hidden assumptions and should not allow them to nurse illusions as to the propriety of applying certain types of calculation in professionally important fields, without clear realization of the factors of ignorance involved. In many of his designs, the engineer of the future will probably not be permitted factors of safety other than unity, and he will therefore have to break with the "elastic continuum" tradition. The writer believes that the sooner we adopt the practice of teaching engineering students, from the start of their training, how complex and varied are the strain responses of metals to stress, the sooner will we have engineers who are prepared to face such a future, where the answers to calculations will have to be exact within definable limits.

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Nuclear Engineering

In your February issue, George S. Emmerson has done an excellent job in his discussion of reactor engineering. However, Mr. Emmerson does express one view, which is rather widely held, and to which I would like to take exception. I believe it is especially relevant to the subject of engineering education. Mr. Emmerson expresses the view in question at two places in his article. "These calculations (i.e., those 'involved in determining the amounts of uranium or its enrichment or its required spacing in the moderator lattice to achieve criticality') are properly the province of the nuclear physicist; . . ." Further on, "The pitch of the lattice is determined by the nuclear physicist from nuclear considerations." It does not seem to me that this point of view is acceptable either to an engineer or a nuclear physicist.

I wonder if Mr. Emmerson's company regards the estimation of plate spacing in a cathode ray tube as "properly the province" of the atomic physicist, or the pitch factor in an electric generator or the blade spacing on a turbine as "properly the province" of the classical physicist? Chemical engineers might wonder to find that the determination of the diameter of tubes in a tubular catalytic reactor is properly the province of the chemist. The obvious question is, "What is unique about nuclear reactor theory which precludes it from incorporation in the body of engineering knowledge in the same manner that other scientific information has been incorporated?" The only reasonable answer that I can find to this question

is, "Nothing." Lattice pitch is determined not alone by nuclear consideration, but by a combination of nuclear, heat transfer, economic, etc., considerations, in the best tradition of engineering design problems.

Mr. Emmerson could undoubtedly make the point that at the present time the man responsible for nuclear calculations in the design of reactors more often than not has a nuclear physics background. I believe this is a temporary situation. No doubt if there had been a tremendous demand to produce a 250,000 KW generator within 10 years after Oersted's discoveries, physicists would have played a major role in the design. By the usual definitions of the practice of engineering those persons whose responsibility it is to determine the lattice pitch of a reactor are functioning in an engineering capacity, no matter what their educational background. An example of such a definition is that due to M. P. O'Brien (JOURNAL OF ENGINEERING EDUCATION, *41*, 133, (1950)): "The activity characteristic of professional engineering is the design of structures, machines, circuits, or processes, or a combination of these elements into systems or plants and the analysis and prediction of performance and costs under specified working conditions." Interestingly enough, very few physics curricula that I know of include reactor theory. Most of the physicists of my acquaintance who work in reactor theory or design have acquired this specialized knowledge since leaving school. While I have no objection to the erstwhile nuclear physicist functioning in this capacity, I do object to the arbitrary exclusion of the engineer from doing likewise.

The thing which concerns me about this view is the implication that here is one aspect of the design of an engineering system which is *not* properly the province of an engineer. Is it too mysterious or beyond his ability to learn? Should we limit reactor theory courses in engineering curricula to the survey, background type? This would seem a particularly poor point of view to adopt when the current advances in nuclear physics give promise of many more engineering systems involving nuclear reactions in the relatively near future. Consequently, I would propose that determination of reactor lattice pitch is properly the province of the engineer. More generally, there is no area of knowledge which is not properly the province of the engineer if this knowledge is necessary to the proper discharge of an engineering function.

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A Note to Thermodynamicists

Why is it that thermodynamicists insist upon doing things the hard way? For example, in a Rankine cycle if one wishes to find the heat to the condenser, they find the entropy of the steam leaving the boiler and set this equal to the entropy of saturated steam at the condenser pressure. Thus they obtain the quality of the steam. Using this quality, the enthalpy of the steam is found. Next, they subtract the enthalpy of the liquid and find the heat to the condenser.

How simple it would be to take the entropy of the steam leaving the boiler, subtract from this the entropy of the saturated liquid leaving the condenser and then multiply this difference by the absolute temperature in the condenser.

In a way just as easy one might find the enthalpy of the steam entering the condenser.

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SOME SHORT CUTS AND CHECKS FOR CONICS

ROSE LARIVIÈRE

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Students of plane analytical geometry are generally reluctant to attempt problems involving extensive computations unless they are supplied with answers, or have been taught easy checks of their accuracy. It is obviously better to provide checks than to provide answers, if the former can be readily applied.

The coefficients of the quadratic terms in x and y of the equation of a conic after the coordinate axes have been rotated to remove the term in xy are quantities for which easy checks are available. If A, B, and C, $(B \neq 0)$, are the coefficients of x^2, xy, and y^2, respectively, in the general equation of the conic $Ax^2 + Bxy + Cy^2 + Dx + Ey + F = 0$ $(A > 0)$, and if A', B', and C' are the corresponding coefficients after rotation, the student will find in his textbook expressions for A', B', and C' obtained by substituting the basic equations of rotation in the equation of the conic. For example, $B' = B\cos 2\theta - (A - C)\sin 2\theta$ (1), where θ is the angle of rotation.

He may be asked to verify new equations for A' and C', $A' = A + \frac{(B + B')}{2} \times \tan\theta$ and $C' = C - \frac{(B + B')}{2}\tan\theta$ (2) by substituting therein the value of B' from (1) and simplifying. When rotation through θ makes $B' = 0$, equations (2) become $A' = A + \frac{B}{2}\tan\theta$ and $C' = C - \frac{B}{2}\tan\theta$ (3), [1].

Since the coefficients of the quadratic terms are independent of the linear in rotation, the student may determine them separately. He may compute the angle of rotation to make $B' = 0$ from $\tan\theta = \frac{C - A}{B} \pm \sqrt{\left(\frac{C - A}{B}\right)^2 + 1}$ (4) or otherwise. (In what follows we shall assume $\frac{\pi}{2} > \theta > 0$ so that the plus sign is to be taken before the radical in (4).) Next, equations (3) give the student A' and C', and the equations of rotation, $x = x'\cos\theta - y'\sin\theta$, $y = x'\sin\theta + y'\cos\theta$, need be applied to the linear terms only to conclude the rotation. Translation may then be performed with ease after the completion of squares.

If $\tan\theta$ contains a radical the equations of rotation may become very unwieldy. In such cases, if $B^2 - 4AC \neq 0$, translation to eliminate the first degree terms precedes rotation. Equations (3), which involve $\tan\theta$ only, are then sufficient for the complete rotation.

When the student has obtained the simplified equation of the conic by methods not described here, he may use (3) and (4) as checks. If (3) and (4) have been used for the primary computation, there still exists an easy check based on invariants. The equation $z^2 - (A' + C')z + A'C' = 0$ has coefficients which are easily found from $(A + C)$ and $B^2 - 4AC$. The roots r_1, r_2 are A' and C' in an order which can now be determined by equations (3) since they show that $A' > A$ if $B > 0$ and $A' < A$ if $B < 0$.

Many less important checks which interest the student are also available, for instance:

When $B^2 - 4AC = 0$ equations (3) show that if $B < 0$ the simplified equation will be $y^2 = 4px$, and if $B > 0$ it will be $x^2 = 4py$. The line $Ax^2 + Bxy$

$+ Cy^2 = 0$ gives the same information since it is parallel to the principal axis of the parabola [2].

When $B^2 - 4AC < 0$, if $B < 0$ the reduced equation of the real, non degenerate ellipse will read $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$, but if $B > 0$ it will read $\frac{x^2}{b^2} + \frac{y^2}{a^2} = 1$.

Finally, when $B^2 - 4AC > 0$, the lines $Ax^2 + Bxy + Cy^2 = 0$ are parallel to the asymptotes. Hence correctly rotated coordinate axes will bisect the angles made by these lines.

References

[1] R. Lariviere, "Reducing the Equation of the General Conic," *Am. Math. Monthly*, vol. 64, 1957, pp. 500–501.

[2] See, for instance, Chas. Smith, *An Elementary Treatise on Conic Sections*, revised edition, Macmillan Co., 1930, pp. 124, 236.

SCIENTIFIC ACTIVITIES IN SIX STATE GOVERNMENTS

A summary report, *Scientific Activities in Six State Governments*, has been released by the National Science Foundation. The report is based on studies of these activities in California, Connecticut, New Mexico, New York, North Carolina, and Wisconsin, selected as representative of major geographical regions, and of varying resources, physical size, and economic characteristics.

Among the findings of the study was the fact that the conduct of research and development in each of the six States accounted for the major share of expenditures for scientific activities in fiscal year 1954. Of a total of $69 million for all scientific activities in the six States, over $57 million was reported as expended for the conduct of research and development. Sixty-three per cent of the $57 million was accounted for by the agricultural experiment stations and the State universities.

Copies are available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. The price is $.40 per copy.

HEAT TRANSFER TEACHING SURVEY

The Heat Transfer Division of the A.S.M.E. is collecting information on graduate or undergraduate laboratory experiments and lecture demonstrations in Heat Transfer. Descriptions of these experiments will be made available eventually to all interested schools through A.S.M.E. channels. If you have developed any particularly interesting or pedagogically valuable heat transfer experiments or lecture demonstrations, please forward this information to Prof. F. Landis, Dept. of Mechanical Engineering, New York University, New York 53, N. Y.

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POSITION AVAILABLE FOR TEACHing undergraduate and graduate courses in fluid mechanics, heat transfer, and directing thesis research. Only applicants with Ph.D. degree considered. Salary compatible with qualifications. Write to Head, Mechanical Engineering Department, University of Kentucky, Lexington, Kentucky.

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ELECTRICAL, INDUSTRIAL, MEchanical, and structural engineering faculty positions are available at the Penn State Centers in various locations in Pennsylvania. Relatively small classes; freshmen, sophomores, and associate degree students. Write to: T. J. Rung, General Extension, The Pennsylvania State University, University Park, Pa.

ASSISTANT PROFESSOR TO TEACH Theory of Structures, Elasticity, Dynamics. Master's degree preferred. Department of Mechanical Engineering, Oregon State College, Corvallis, Oregon.

HEAD OF MECHANICAL ENGIneering in rapidly growing department in the Rocky Mountain Region. Ph.D. desired. New building to be constructed next year. Salary $8,000 to $9,500 on a 9 month's basis. Apply: Dean of Engineering, Utah State University, Logan, Utah.

MECHANICAL ENGINEERING—Assistant or Associate Professor to teach thermodynamics and heat transfer. M.S. degree required, Ph.D. desirable. Rank and salary commensurate with qualifications. Positions available September 1, 1959. Write E. R. Stensaas, Head, Department of Mechanical Engineering, South Dakota School of Mines, Rapid City, South Dakota.

ASSISTANT OR ASSOCIATE PROFESSOR with Ph.D. in electrical engineering and strong training in electronics and communications. Combination of good industrial and teaching experience desirable. Successful applicant will be expected to develop curriculum and laboratory facilities and teach in new electronics program. Apply to President Guy A. West, Sacramento State College, Sacramento 19, California.

ELECTRICAL AND MECHANICAL engineering openings for 1959. Junior work to be offered for first time in September. Unlimited opoprtunities to advance. M.S. or Ph.D. required. Rank and salary dependent on training and experience. Apply to Dr. J. R. Wolf, President, Arlington State College, Arlington, Texas.

TECHNICAL DRAWING INSTRUCTOR needed beginning in September, 1959. Applicant may be a young engineering graduate without teaching experience, but with a good scholastic record. Instructor may work toward Masters degree in Engineering Graphics while teaching. Write Prof. H. C. Spencer, Director, Technical Drawing Dept., Illinois Institute of Technology, Technology Center, Chicago 16, Illinois.

CIVIL ENGINEER—STRUCTURES. Beginning fall 1959, permanent position on expanding staff. Ph.D. degree desired, M.S. required. Graduate teaching and advising, with some undergraduate courses. Opportunities for research. Rank and salary will depend on qualifications. Write Chairman, Department of Civil Engineering, University of Missouri, Columbia, Missouri.

TEACHING POSITIONS AVAILABLE in Mechanical Engineering. Two additional staff are needed, one in the Machine Design and Dynamics of Machines area, another in the Heat Power area to include supervision of laboratories. Salary and rank dependent upon education and experience. Address—Head, Mechanical Engineering Department, Lafayette College, Easton, Pa.

EXPANDING TWO-YEAR COLLEGE of State University of New York seeks full-time teachers in both ELECTRICAL and MECHANICAL TECHNOLOGIES. B.S. necessary. Master's degree and/or teaching experience helpful. Salaries for those with advanced degrees and industrial experience start above $7,000. Write: W. R. Pulhamus, Head, Electrical Technology Dept. or B. G. Davis, Head, Mechanical Technology Dept., Mohawk Valley Technical Institute, 751 State Street, Utica, New York, Tel. RE 3-0451.

PHYSICS DEPARTMENT IN FULLY accredited engineering college with strong undergraduate and M.S. programs in physics has staff vacancy. Offers opportunity for research and association with a young, lively departmental faculty of ten (including seven Ph.D.'s). College is located in a village of 7000 which is also the site of a state teachers' college, and is 10 miles distant from a fine liberal arts college. It is within 15 miles of the St. Lawrence Seaway and Power Projects and the Adirondack Mts. Ph.D. desirable, M.S. essential. Write T. S. Renzema, Clarkson College of Technology, Potsdam, New York.

THERMODYNAMICS PROFESSOR required immediately at the Assistant or Associate level. Salary of $8,000–$10,500 includes summer research stipend. Doctor's degree preferable, genuine research interest imperative. Opportunity to equip laboratories for instruction and research in new Engineering building. Nuclear research centre, including reactor, on campus. For more information, write Dr. J. W. Hodgins, Dean of Engineering, McMaster University, Hamilton, Ontario, Canada.

SECTION MEETINGS

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Pittsburgh, Pa.	June 15, 1959	J. R. Smith, Univ. of Pittsburgh
Illinois-Indiana	Bradley University	May 9, 1959	R. E. Gibbs, Bradley University
Kansas-Nebraska	Univ. of Kansas	Oct. 1959	J. S. Blackman, Univ. of Nebraska
Michigan	Lawrence Inst. of Technol., Detroit	May 9, 1959	M. M. Ryan, Lawrence Institute of Technology
Middle Atlantic	U. S. Military Academy, West Point, N. Y.	May 9, 1959	K. J. Moser, Stevens Institute of Technology
Missouri-Arkansas	University of Missouri Columbia, Mo.	1960	Joseph C. Hogan, University of Missouri
National Capital Area	Ft. Belvoir, Va.	May 13, 1959	K. C. Harder, Office of Naval Research, Navy Dept.
New England	Univ. Connecticut	Oct. 16–17, 1959	G. A. Marston, Univ. of Mass.
North Midwest	Iowa State	Oct. 16–17, 1959	E. H. Ohlsen, Iowa State College
Ohio	Univ. of Dayton	Spring, 1960	N. R. Rimboi, Fenn College
Pacific Northwest	Montana State College	May 8–9, 1959	G. J. Herman, Montana State College
Pacific Southwest	Los Angeles State College	Dec. 28–29, 1959	Bonham Campbell, UCLA
Rocky Mountain	U.S. Air Force Academy	Apr. 29–30, 1960	Archie Higdon, U.S. Air Force Academy
Southeastern	University of Alabama	April 2–3, 1959	J. C. Reed, Univ. of Florida
Southwest	New Mexico A & M	Mar. 26–27, 1959	I. W. Santry, Southern Methodist U.
Upper N. Y.-Ontario	Rensselaer Polytechnic Institute	Oct. 1959	W. W. Shuster, Rensselaer

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ENGINEERING DOCTORATE NOW OFFERED AT WAYNE

Approval of a Doctor of Philosophy program in chemical and metallurgical engineering was given by Wayne State University's Board of Governors at its February meeting.

Under study for a number of years, the program initially will be limited to key younger men who are combining instruction and work on their Ph.D. degrees. At first the total number will not exceed six in chemical and four in metallurgical engineering.

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